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PUBLISHER'S ANNOUNCEMENT

Surgical Progress for 1951 is the first of an annual series of supplementary volumes to *British Surgical Practice*. It is designed to keep the eight main volumes up to date in an ever-increasing field of surgical knowledge. This is being done in three ways—by original articles, critical surveys and abstracts.

Subscribers to the main work will find reference to this supplementary volume much facilitated by the provision of a "Noter-up" section, and a correct understanding of the method of its use will considerably enhance the value of both the main work and *Surgical Progress*. It will, moreover, save a great deal of time.

Non-subscribers will find the "Noter-up" section of value in that it is alphabetically arranged and gives at a glance information as to the presence or absence of recent material on any particular subject. Consequently, the book can be used independently.

Every article in the main volumes of *British Surgical Practice* has a Key Number, which appears at the commencement of each article and also at the top left-hand corner of every right-hand page. In order to ascertain whether there has been any recent advance in the particular subject to which reference is being made, the reader should merely turn to the appropriate Key Number which appears in the outer margin of the "Noter-up" section. He will there find either a note that no further references appear or information as to the type of new matter incorporated by way of article, survey or abstract. This is amplified by a brief outline of the content of the recent addition.

Subscribers who turn direct to the abstract section will find that there also the keyed arrangement has been followed

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September, 1951

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NOTER-UP, 1951

INTRODUCTION

KNOWLEDGE increases as the result of practical experience and scientific research; teaching and practice must be modified to accord with new developments. Comparatively rarely the practice of surgery undergoes a sudden alteration because of the introduction of an entirely new method, but as a rule changes take place gradually by minor modifications of technique or management—often so gradually that it is only by reference to recently published articles which have already become out of date that changes of method or doctrine can be appreciated. The need for continual revision of and addition to BRITISH SURGICAL PRACTICE is obvious, and it is our intention to publish annually an account of SURGICAL PROGRESS which, though labelled with a date, will not deal only with the changes which have occurred in the practice of surgery in the course of that particular year.

The present volume for 1951 contains several articles intended to make good certain deficiencies in the original volumes of BRITISH SURGICAL PRACTICE—such are those on adrenal phaeochromocytoma, painful amputation of stumps, innocent lumps in the breast and spondylolisthesis. Others introduce entirely new matter—for example, the articles on antibiotics, flash burns, reconstruction of the trachea and stress incontinence. The remainder are intended to modify or amplify articles on the same subjects in the original work—appendicitis, the anatomy of the autonomic nervous system, acute infections of bone, hernia, Hirschsprung's disease, arterial surgery, coagulants and anticoagulants, injuries of the hand and the use of radioactive isotopes.

With regard to the Abstracts it will be noticed that a high proportion come from the less well-known publications. We have assumed that our readers would be familiar with the contents of the leading surgical journals which must be generally accessible.

We would like to express our gratitude to the reviewers of BRITISH SURGICAL PRACTICE whose comments have helped us to see where there are gaps to be filled and to recognize the subjects which have to be brought up to date.

E. ROCK CARLING.
J. PATERSON ROSS.

ADRENAL GLANDS–PHAEOCHROMOCYTOMA

BY L. R. BROSTER, O.B.E., D.M., M.CH.(OXON), F.R.C.S.(ENG.), F.A.S.A.
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INTRODUCTION

Abnormal variations in blood pressure are often found in pathological states of the adrenal gland. In Addison's disease the blood pressure is low; in cortical hyperplasia (Cushing's syndrome) it is raised; in phaeochromocytoma it is high, either in paroxysms or permanently. Sudden crises affecting blood pressure may be dangerous complications common to both Addison's disease and phaeochromocytoma.

Phaeochromocytoma (chromaffinoma or paraganglioma) is a rare tumour, usually arising in the adrenal medulla. It gives rise to the classical adreno-sympathetic syndrome characterized by bouts of hypertension, and if untreated will sooner or later prove fatal. On the other hand, removal of the tumour results in cure, but the diagnosis of the syndrome may be so obscure that the most careful history, examination and investigation will give no clear answer.

In the past, phaeochromocytoma was recognized as a post-mortem curiosity, as the cause either of sudden and unexplained death or of unexpected death on the operation table. During the last two decades our knowledge of its clinical manifestations has grown considerably from sporadic and scattered reports in the literature, and its earlier recognition and treatment are leading to a higher percentage of cures. The subject received a great impetus when it became known that these tumours secreted adrenaline and *nor*adrenaline as the causative factors of the hypertensive attacks. Indeed, the more recent publications show marked progress in improved methods of investigation, diagnosis and treatment and in the correlation of different aspects of the syndrome. Especially is this so in the biochemical sphere, where recent advances may well lead to some adjustment of our ideas on the subject of hypertension in general. The management of a patient with phaeochromocytoma requires teamwork in which the surgeon has an important and responsible part to play, and this contribution is presented in the form of a general survey in order to emphasize such points as are his particular concern.

HISTORICAL

In 1886 Frankel reported the post-mortem findings of bilateral adrenal tumour associated with the adreno-sympathetic syndrome.

According to MacKeith (1944) it was known some 30 years ago that some phaeochromocytomas gave positive reactions to chemical tests for adrenaline. These results, of varying quantitative estimations of a pressor substance behaving like adrenaline, have now been confirmed. In 1922 the first clinical description was given of a unilateral tumour in a woman of 28 years, with headache, vomiting, tremor, palpitation and hypertensive paroxysms (Labbé, Tinel and Doumer, 1922). In 1929 the first correct diagnosis followed by operation and cure was reported (Pincoffs, 1929). In 1937 adrenaline was found in the blood during a hypertensive crisis (Beer, King and Prinzmetal) and in 1949 the quantitative assay of adrenaline and *nor*adrenaline in the tumour was given from three cases of phaeochromocytoma by Holton. In 1950

Engel and von Euler stated that by estimating the total output of *nor*adrenaline and adrenaline in the urine a reliable diagnosis of phaeochromocytoma may be obtained.

CLINICAL SYNDROME

The diagnosis of phaeochromocytoma may be easy or extremely difficult. It is easy when the classical adreno-sympathetic syndrome is present, that is, when certain symptoms occur in conjunction with a sudden and observed rise in blood pressure and disappear when it falls. The commonest of these symptoms are headache, palpitation, tachycardia, dizziness and abdominal or praecordial distress amounting to pain, nausea, vomiting and sweating. These are not necessarily all present. They should be associated with signs of peripheral vasoconstriction. The diagnosis is difficult when the exceptions to this rule occur, namely:

(a) There may be no symptoms, and the patient may die suddenly or during operation—the type disclosed only at necropsy.
(b) The hypertension may be persistent, either in the later stages of the paroxysmal type or without previous paroxysms.
(c) As a rule, the malignant types do not give hypertensive crises nor do their metastases, although paroxysms tend to occur with those tumours that are locally invasive.
(d) The condition may simulate Addison's disease from pressure on the cortex.

In such exceptional circumstances the symptoms may be extremely varied and widespread, ranging from the subjective and emotional, which may lead to a diagnosis of psychoneurosis, to unrelated and equivocal complaints, the underlying physiological mechanism of which is not at all clear. These patients should be carefully investigated, and a diagnosis made before irreversible cardiovascular disease has set in.

Paroxysms

Paroxysms may be spontaneous or induced and the duration of an attack may be fleeting or prolonged, lasting from a few minutes to several days. As a rule the attacks become more frequent and last longer with the passage of time, and the hypertension may become persistent in the later stages. Between attacks the patient is normal. In 75 per cent of cases phaeochromocytomas are associated with paroxysmal crises. On the other hand, there are some patients with essential hypertension who have paroxysmal spells but who do not have phaeochromocytomas. The hypertension may be symptomless or death may follow the first attack. Occasionally the hypertension is persistent and does not vary; this is more common in children. In malignant phaeochromocytomas hypertension may be absent. As a rule the attacks come on spontaneously. Several causes which are said to induce an attack have been described as follows: postural factors, such as lying on one side or the other, bending, or combing the hair; active interference, such as pressure, manipulations, intravenous medication, spinal anaesthesia or operations; and indefinite stimuli, such as straining, over-eating, constipation, cold baths, altitude, painful stimuli or emotion.

Some writers describe a prodromal stage and others draw attention to a stage of reaction after the attack, so for the sake of clinical clarity it is wise to divide the paroxysm into three stages—like that of an epileptic fit.

Prodromal stage

During the prodromal stage there may be a definite aura, while the blood pressure is rising. Various symptoms have been described—malaise, languor, tremor, and numbness or tingling of the extremities. Patients may also complain of subjective symptoms, such as restlessness, nervousness, excitability, anxiety, apprehension mounting to fear or a feeling of impending death.

The paroxysm proper

During the attack, which may be fleeting or more prolonged, the patient is ill. Apart from the more common symptoms enumerated above, others that have been described follow no sequence or regularity and are best considered in relation to their various systems.

Cardiovascular system.—There may be a sense of constriction, choking or surging in the chest and neck, with substernal or praecordial pain radiating down the arms like typical anginal attacks.

The heart beats are forcible and there is generally palpitation and tachycardia. The pulse may be small or hard. The blood pressure rises quickly from 120/80 to 300/180 or more, according to the severity of the attack. The signs of peripheral vasoconstriction may be the most outstanding feature of the attack. There is generally pallor of the extremities and face; sometimes there is blotchiness or pallor alternating with blueness. Numbness, tingling and cramps may be present.

Nervous system.—Headache is common; it may be very severe, generalized, vertical or occipital in distribution. There may be dizziness, tinnitus or throbbing over the temples associated with weakness and tremor. Ocular manifestations such as spots before the eyes, blurred vision and dilated pupils may occur. There may be gooseskin, shivering and sweating.

Alimentary system.—There may be nausea, vomiting, excessive thirst, a sinking feeling, discomfort, distress or pain in the epigastric region. Pain may also be present in the lumbar region.

Respiratory system.—Dyspnoea is a fairly common symptom and haemoptysis from pulmonary oedema has been described.

Cutaneous system.—Neurofibromatosis and pigmentation may be present.

Urinary system.—Sugar, albumin and casts may be present. The blood urea may be raised. An intravenous pyelogram may show lessened secretion in one kidney or a downward displacement of the upper calyx or kidney.

Stage of reaction

After the blood pressure has subsided and according to the severity of the attack the following symptoms have been described: flushing of the face and neck, salivation, lacrimation, sweating and dilatation of the pupils. There may be fatigue, lassitude, weakness, a feeling of complete exhaustion with loss of consciousness and a cold clammy shock.

Clinical findings

Ophthalmic changes

The fundi may be normal or show well-marked changes due to sclerosis. [illegible] ad to early and correct diagnosis. [illegible] hypertension is more likely to be [illegible] ant pattern; haziness of the disc, blurred margins, papilloedema, exudates, flame-shaped haemorrhages, arterial spasm, and congestion of the vessels have all been reported.

Cardiovascular system

The left ventricle may be enlarged and there may be a systolic murmur or extrasystoles. The electrocardiogram may be normal and does not conform to any definite type or one of diagnostic value. Readings vary during and after attacks and may simulate coronary disease.

The most common finding is left axis deviation, with inverted T waves and

prolongation of S–T interval after an attack. Recordings show various types of arrhythmia with QRS slurring and various T waves during an attack.

A detailed account of the electrocardiographic changes is given by Mac Keith (1944).

Glycosuria

The effect of injecting adrenaline is to liberate sugar stored in the liver and muscles into the blood stream, but the effects of the pressor substances secreted by phaeochromocytomas are variable and show biological inconsistencies. According to Smithwick and his colleagues (1950) glycosuria is present in 36 per cent of phaeochromocytoma patients and in 4 per cent of patients with essential hypertension. During an attack of paroxysmal hypertension a fasting blood sugar of over 120 milligrams per 100 millilitres with glycosuria is present in 50 per cent of patients with phaeochromocytomas. Hyperglycaemia is more commonly found than actual glycosuria, and is more common in adults than in children.

This hyperglycaemia may or may not respond to insulin. De Vries, Rachmilewitz and Schumert (1949) record two cases of phaeochromocytoma in which the hypertensive attacks were associated, in one with hyperglycaemia and glycosuria, and in the other with persistent diabetes. Both were cured by the removal of the tumour.

A typical finding is 150 milligrams per cent fasting sugar, which rises to 206–270 milligrams per cent after the administration of 50 grammes of glucose.

Blacklock and his colleagues (1947) describe a patient in whom the islet tissue was hyperplastic with an increase in the number of islets. In this patient half-hourly sugar readings after 50 grammes of glucose were 147, 92, 70 and 70 milligrams per cent, with a fasting blood-sugar level of 70 milligrams per cent.

CLINICAL INVESTIGATIONS

Inducing an attack

An attempt may be made to induce an attack by bimanual pressure or by the patient's own effort of squeezing the adrenal by bending his trunk.

Temperature

The patient's temperature may be slightly raised in essential hypertension or between attacks in phaeochromocytoma, but during an attack it may rise to 105° F., by reduction of the heat loss due to peripheral vasoconstriction.

Cold test

When one hand is immersed in ice-cold water for 1 minute a rise in blood pressure of over 20 mm. Hg. systolic and 15 mm. Hg. diastolic may be considered abnormal. This rise is found in only 15 per cent of normal patients but in 90 per cent of those with hypertension, particularly when this is due to phaeochromocytoma.

Basal metabolic rate

A rise of 20 per cent or more is a feature of phaeochromocytoma. It is said to be present in 57 per cent of these cases and varies with the output of adrenaline.

Postural tachycardia and hypotension

The blood pressure and pulse rate are taken every minute for 5 minutes, lying, sitting and standing.

A reduction in blood pressure and a pulse rate raised by over 20 in the erect position, when compared with that lying or sitting, is more likely to occur in phaeochromocytoma, whereas it is unusual in essential hypertension.

Radiography

A good plain x-ray film in a thin person may show up a small tumour the size of a walnut. If not, an intravenous pyelogram should be performed. Depression of the upper calyx or of the kidney is strongly suggestive of an adrenal tumour, but is not diagnostic.

Radiography may be combined with perirenal insufflation. Cahill (1948) is a strong advocate of this method, but it has not met with the same success in the hands of other surgeons, and may induce unpleasant and dangerous paroxysms.

BIOCHEMISTRY

Adrenaline

The biochemical study of the adrenaline-like pressor substances secreted by phaeochromocytomas is of comparatively recent date. The position is still fluid and further discoveries may throw new light on the subject. Although adrenaline was found in the blood during a hypertensive attack in 1937 (Beer, King and Prinzmetal), this test is still a difficult one to perform and, except in special laboratories, is not generally available for clinical use. The amount of adrenaline in the blood of a normal resting patient is so small as to have no demonstrable activity. When injected intravenously it raises the blood pressure, yet one case is quoted (Walton, 1950) in which it failed to do so during and after an operation for removal of phaeochromocytoma.

On the other hand, adrenaline is more readily recovered from the tumour. The amount varies from 0·12 to 20 milligrams per gramme of tumour. The following list sets out some of the results obtained.

Date	*Author(s)*	*Tumour, grammes*	*Adrenaline, milligrams per gramme*
1944	Broster and MacKeith	63·5	5·25 estimated from the colour reaction with iodine 8·00 by biological test
1947	Spalding	86	5·00
1949	Lovell	1,100	0·32 adrenaline 5·30 *nor*adrenaline
1949	de Vries, Rachmilewitz and Schumert	30·0	7·0 (patient with diabetes)
1949	de Vries, Rachmilewitz and Schumert	95·0	2·0 (patients with hyperglycaemia and glycosuria)
1950	Mahru and Carroll	92·0	1·53 adrenaline 2·47 *nor*adrenaline Giving a total content of 141 milligrams adrenaline and 227 milligrams *nor*adrenaline
1950	Engel and von Euler* (1)	48	4·5 adrenaline, 0·05 *nor*adrenaline
1950	Engel and von Euler (2)	–	0·75 adrenaline, 0·75 *nor*adrenaline

* The proportion of *nor*adrenaline and adrenaline found in the urine was approximately the same as in the tumour, and both fell in amount after removal of the tumour

Potassium

A significant rise in the blood potassium has been recorded in several cases, and when present is of considerable diagnostic importance.

Anti-adrenaline compounds

Certain dioxane compounds have anti-adrenaline properties. Of these benzodioxane (933F), first synthesized by Fourneau and Bovet (1933), was shown to counteract some of the effects of adrenaline infused into the bloodstream of dogs (de Vleeschhouwer, 1934). Benzodioxane abolishes the effect of adrenaline by blocking its action at the effector cell. It blocks the action of circulating adrenaline more readily than

that of adrenaline liberated at the nerve ending because in the former case the concentration of adrenaline at the site of action is lower than it is at the nerve ending. Renal hypertension in animals is not significantly influenced by these drugs.

It is too early to be dogmatic about the effects of these drugs in clinical trials. When injected their general effect is to prevent the hypertension produced by adrenaline. Their effects may be summarized as follows.

In normal individuals the blood pressure is slightly raised.
In essential hypertension it is raised.
In phaeochromocytoma the blood pressure is lowered within 15 minutes.
Unpleasant effects may be produced and the drug should be used with caution.

Mahru and Carroll (1950) report that Priscoline in divided doses decreased the frequency, severity and duration of hypertensive attacks before operation for phaeochromocytoma.

No treatment of a phaeochromocytoma by the continuous administration of an anti-adrenaline drug has yet been reported.

SPECIAL TESTS

Three chemical tests to aid in diagnosis have been suggested:

(1) The histamine test (Roth and Kvale, 1945).

(2) The benzodioxane (933F) test (Goldenberg, Snyder and Aranow, 1947).

(3) The TEAB (tetraethylammonium bromide) test (Lyons and his colleagues 1947).

The histamine test is designed to evoke a paroxysm in patients with phaeochromocytoma. The benzodioxane test is designed to detect hypertension due to an excess of circulating adrenaline rather than to overaction of the sympathetic system, and hence is positive in phaeochromocytoma. The TEAB test is the converse of the benzodioxane test, for it detects essential hypertension due to sympathetic overactivity.

At the moment the author would certainly recommend the histamine and TEAB tests. The benzodioxane test should also be tried even though the valuable results reported in the United States of America have not as yet been regularly obtained from its use in Great Britain and severe reactions sometimes have been seen, for it may prove very helpful in an individual case and further observations on its use are needed.

The histamine test

The patient lies at rest for 30 minutes so that a stable base line of systolic and diastolic blood pressures is obtained. Histamine, 0·05 milligram in 0·5 millilitre of normal saline solution is given rapidly intravenously and the blood pressure and other changes are observed. In normal people and in essential hypertensives there is an immediate small fall of blood pressure for a minute or so and the patient may complain of a headache which lasts longer. Thus in a case of essential hypertension the figures obtained were as follows:

	Blood pressure
Before injection	230/145
1 minute after	180/110
2 minutes after	240/150
4 minutes after	225/130

In a phaeochromocytoma patient there will be a rise in blood pressure of 50–100 mm. Hg. and the concomitants of a typical paroxysm. The value of the test in

phaeochromocytoma has been confirmed by Calkins and Howard (1947) and Smith, Logue and Beard (1950).

The benzodioxane (933F) test

The benzodioxanes reverse the pressor effect of adrenaline in animals (Fourneau and Bovet, 1933). Goldenberg, Snyder and Aranow (1947) described the use of one of this group of drugs as a test for hypertension due to circulating adrenaline. 933F (2[1 piperidylmethyl] 1 : 4 benzodioxane) abolishes the rise of blood pressure caused in normal persons by intravenous infusions of adrenaline and also the hypertension

[illegible]

phaeochromocytoma. However, Dana and Calkins (1949) have reported a "positive" result, that is a fall in blood pressure, in a case not having a phaeochromocytoma and Wilson (1950) a "negative" (a rise in blood pressure), in a man with a phaeochromocytoma and hypertension. In Mac Keith's experience and in that of Prunty and Swan (1950) the 933F at present obtainable in Great Britain is liable to give *more severe reactions and otherwise different results from those reported by* Goldenberg.

The technique of the 933F test is as follows:

The dose is 0·25 milligram per kilogram of body-weight or 10 milligrams per square metre of body surface. It is important that no sedatives be given, especially Sodium Amytal, for if sedatives are given a fall in blood pressure may be produced by 933F even when the hypertension is not due to circulating adrenaline substances. A slow intravenous drip of normal saline solution is set up and through a two-way tap the drug is given slowly as a 1 per cent solution (for example 15 milligrams in 1·5 millilitres) taking about 2 minutes. Side effects such as flushing, feeling hot, palpitations, tachycardia, a sinking feeling or a sensation of anxiety may occur and are especially liable to do so if the injection is given quickly. A lasting headache may follow the injection.

Where the hypertension is due to phaeochromocytoma, the blood pressure falls in about 5 minutes by some 50 mm. Hg., returning to normal in 15–40 minutes. This is called a positive result. In essential hypertension the blood pressure rises, that is, the result is negative.

TEAB *test*

The TEAB test is similar to the histamine test and may be useful in distinguishing between essential hypertension and phaeochromocytomas. In the former condition, by blocking sympathetic ganglionic activity TEAB will cause a fall in blood pressure, in the latter it directly stimulates the adrenal medulla and the tumour to produce a dramatic rise in blood pressure. The reason for this is unknown.

Dibenamine

Dibenamine is another drug which has been used for reducing blood pressure. It offers not only a test but is the only known way of terminating a dangerous hypertensive crisis in phaeochromocytoma. It has also been used an an operative "umbrella". The drug is given as 7 milligrams per kilogram of body-weight in a litre of saline solution intravenously in one hour. Spear and Griswold (1948) caused a fall in blood pressure of 50 mm. Hg. to normal for 24 hours with an absence of symptoms for 72 hours. The histamine test, which was positive beforehand, was negative during the test.

PATHOLOGY

Tumours of the adrenal medulla have a developmental origin. The parent cell of the medullary epithelium is the undifferentiated sympathogonia. This gives rise to the more differentiated sympathoblast, which forms the neurogenic tumours, such as neuroblastoma or ganglioneuroma; or to the phaeochromatoblast, from which phaeochromocytoma is derived. From the phaeochromatoblast the phaeochromocyte, the chromaffin or chromatic cell develops. These may be found all along the sympathetic system, occurring in the ganglia as nests. The chromaffin system also includes the adrenal medulla, the carotid body, the organ of Zuckerkandl and two chromaffin bodies lying in front of the aorta near the inferior mesenteric artery. Chromaffinomas arising in the carotid body do not secrete adrenaline, but those in the organ of Zuckerkandl may or may not do so (Ganem and Cahill, 1948).

As a rule, tumours arising in the adrenal medulla are known as phaeochromocytomas or chromaffinomas, and those arising elsewhere as paragangliomas.

Histological investigation of chromaffin tissue demands special methods. The cells turn brown with potassium bichromate. The colour is due to a precipitate in the cells and is known as the chromaffin reaction. Adrenaline granules are present in the cells. Blacklock and his colleagues (1947) recommend fixing in bichromate, placing sections in 0·2 per cent potassium permanganate, rinsing in 1 per cent oxalic acid and then proceeding with Sevki's modification of Schmorl's Giemsa method, which shows up these granules olive-green in colour. They may be seen passing from the tumour cells into the capillaries.

Macroscopically a phaeochromocytoma is either wholly or partially encapsulated. The surface is smooth or bossy and the tumour often consists of haemorrhagic purplish cysts within a fibrous stroma. The cortex is stretched circumferentially over the tumour, its cells may be compressed and their secretion abnormal in amount. The tumour is very vascular, and the cells lie in close contact to the capillaries and numerous blood spaces, giving a pseudo-rosette appearance. Microscopically the cells vary in size and shape. There are large polyhedral cells, with abundant cytoplasm, some multinucleated, some compressed into spindle cells and others in various stages of maturity. Mitoses may be present, and the diagnosis of malignancy may be difficult.

Tumours arising in the adrenal medulla are mostly unilateral and benign, varying in size from 13 to 200 grammes by weight, and occurring between the ages of 16 and 82 years. They are twice as common in the right adrenal, and Blacklock and his colleagues (1947) give the relative order of frequency in the proportions of right adrenal 5, left adrenal 3 and bilateral 1.

About 10 per cent are malignant and 10 per cent bilateral. The former usually give no hypertension, nor do the metastases produce the typical syndrome after removal of the primary growth. Tumours may be multiple.

Extra-medullary tumours, apart from those mentioned above, have been described in the first and sixth intercostal spaces and in the cranial cavity (Ganem and Cahill, 1948; Smithwick and his colleagues, 1950).

DIFFERENTIAL DIAGNOSIS

The differential diagnosis is mainly medical. Paroxysmal hypertension may occur in such conditions as essential hypertension, angina pectoris, eclampsia and tabes dorsalis. Other conditions such as diabetes, hysteria and cardiac neurosis may be simulated by adrenal sympathetic tumours.

From the surgical point of view essential hypertension and thyrotoxicosis are the most important.

TREATMENT

It should be noted that a number of patients have died while in hospital undergoing investigation or awaiting operation. The investigations should therefore not be prolonged unnecessarily, nor operation delayed once a decision has been reached on its desirability.

When all the available evidence points to the presence of a tumour, there remains the question of its localization, and this may be a difficult problem, especially when the tumour is small. In these circumstances an exploratory laparotomy is necessary, and both adrenals should be palpated. On one occasion during the World War II, in similar circumstances, the author thought the right adrenal was slightly thicker than the left, and on giving it a firm squeeze the anaesthetist was able to register a sharp rise in blood pressure from 158 to 180 systolic. A fortnight later a small cystic phaeochromocytoma twice the size of a thumb-nail was removed with the right adrenal.

The treatment is surgical and results in cure. When tumours are large and firmly wedged under the cage of the diaphragm a paramedian abdominal incision with a cross-cut gives the best approach and the easiest access to the adrenal vein, which should be ligated before the tumour is manipulated. The removal of tumours on the right side is easier and gives less shock than the removal of those on the left side.

On the other hand, most phaeochromocytomas are less bulky and should be approached through a high kidney incision, either by removing the last rib when it is small, or by cutting it and restoring its continuity when closing the wound.

As the adrenal vein lies medial to the tumour its ligation can be achieved only after a certain amount of manipulation of the tumour. The less the manipulation the less the spread of adrenaline into the system. In highly active tumours this may give an alarming rise of blood pressure.

This rise of blood pressure is followed by a rapid drop soon after the tumour is removed. The drop should be corrected by giving 10 millilitres of 1 : 100,000 adrenaline hydrochloride in normal saline solution intravenously (Broster and Mac Keith, 1944). It may be necessary to inject adrenaline to counteract any fall of blood pressure during the next 48 hours. On the other hand, another procedure which may be used pre-operatively to counteract the rise of blood pressure caused by manipulation of the tumour is either infiltration of the splanchnics with local anaesthesia or the administration of benzodioxane (933F) The effect of 933F is short and lasts about 15 minutes. Goldenberg and his colleagues have (1949) shown that *nor*adrenaline, being a pure constrictor agent, is a more satisfactory drug to maintain blood pressure than infusion by adrenaline, which relies largely upon the increase of cardiac output. *Nor*adrenaline may be given as 4 millilitres of a 1 : 1,000 solution in 1 litre of normal saline solution at a rate of 2 millilitres per minute according to the response. Some surgeons give Eucortone in addition to the adrenaline. This, theoretically, should not be necessary if the opposite adrenal is functioning normally, but should certainly be used when there is any sign of cortical deficiency, especially in bilateral disease. No hard-and-fast rules can be laid down in maintaining delicate balances by means of drugs which have not yet emerged from the experimental stage.

If the removal of a tumour fails to reduce the blood pressure, the presence of a second tumour must be suspected.

Anaesthesia

The general consensus of opinion is that the ordinary routine methods of anaesthesia are satisfactory, although some prejudice is expressed against the use of spinal anaesthetics.

PROGNOSIS

Removal of a phaeochromocytoma results in cure. It may be followed by recurrence of hypertension in cases in which there is a second unsuspected tumour, or in cases which have had sustained hypertension before operation.

(*See also British Surgical Practice:* Adrenal glands, Vol. 1, page 94, S. Key 12.)

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AMPUTATIONS—PAINFUL STUMPS AND PHANTOM LIMBS

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THE PHANTOM LIMB

After amputation most patients are conscious at some time of the missing limb, and indeed the sensation is often so vivid that an attempt is made to walk on the absent foot or grip with the absent hand. Weir Mitchell (1872) was the first to draw attention to the great frequency of phantom limb sensations and Leriche (1939) reports them in 98 per cent of cases. Of the many theories that have been propounded to explain this phenomenon*, the most satisfactory is that it is due to the existence of the "body image" (Riddoch, 1941), which has been built up as a result of experience in early life, and which has its physical basis in the opposite cerebral hemisphere. The body image is not altered by amputation as such, and consequently nervous impulses derived from cut nerves and neuromas growing from them continue to be appreciated as sensations referred to the absent limb.

The phantom limb may be felt in its entirety, but more commonly the patient is *conscious only of certain parts, chiefly those which during life were most highly* trained in precision and sensibility. Thus, in the upper limb the parts felt are, in order of frequency, the thumb and forefinger, the remaining fingers, the palm, the wrist, the elbow and the forearm. In the lower limb the order is great toe, remaining toes, the medial border of the foot, the ankle, the knee and the leg.

The amount of the phantom limb that is felt and the prominence that it has in *consciousness vary spontaneously to a great extent and can be temporarily altered by* stimulating a neuroma or by interrupting the somatic or sympathetic nerve supply to the stump.

The sensation in the uncomplicated phantom (*see* Henderson and Smyth, 1948) is generally painless and is usually described as a fine tingling, often accompanied by and almost indistinguishable from a sensation of continual fine movements of the digits. Typically the phantom appears immediately after amputation or within a few weeks, and is at first of the same dimensions as the normal limb. Gradually, during a period of time which varies from a few weeks to many years, the phantom shortens and becomes less pronounced, so that at last the digits are felt indistinctly at the end of the stump and finally disappear. It has been suggested that the phantom is felt in the position in which the patient last saw his limb, but this is by no means always the case; the upper limb is generally felt with the fingers semi-flexed and the hand lying across the front of the chest as though the elbow (which may not be felt) is flexed at a right angle, and the lower limb is generally felt in the normal resting position and posture. The phantom generally appears to move with the stump so that their relationship in space is maintained, and one patient with a mid-humerus amputation used to amuse himself by rotating the stump at the shoulder, so passing his phantom hand

* Lord Nelson found in his phantom fingers proof of the existence of the soul.

through his own chest. Many patients feel that they can move their phantom digits, but usually through only a few degrees.

PAIN

The amputee may suffer pain which varies greatly from case to case, but in the worst instances the patient's plight is a sorry one, similar to that seen in severe causalgia (*see British Surgical Practice*, Vol. 6, p. 423). Many personal, psychological and climatic conditions influence the severity of the pain, but this does not justify the conclusion that the pain is psychologically produced, for these factors are well known to alter thresholds in the central nervous system. The incidence of pain is difficult to assess, estimates varying from 15 per cent to 50 per cent. The latter figure is probably considerably too high, but the proportion will be markedly affected by the age of the patient and the length of follow-up, for though pain may occur immediately after operation, its appearance may be delayed for many years. The type and site of pain have prognostic and therapeutic significance. The occurrence of jactitations (so-called "epilepsy") of the stump usually indicates that the pain is very severe, but the unceasing purposeless movements described by Weir Mitchell as chorea of the stump are not necessarily associated with pain.

Pain felt in the phantom

Pain felt in a phantom limb is usually of one of the following five types.

Pins and needles.—This is an exacerbation of the tingling commonly found in the phantom. It is continuous, uncomfortable and distracting, but less severe than other types of pain.

Aching pain.—This pain is constant, varying in intensity but never leaving the patient entirely. It is sometimes burning in character, and suggests the counterpart in a phantom of causalgia in an existing limb.

Lancinating pains.—These knife-like or cutting pains shoot into the phantom and are often of the utmost severity. They tend to occur in bouts during which the pain recurs two or three times a minute for a few minutes or for several hours. These bouts first appear infrequently at intervals of perhaps years but later may become frequent and at intervals of only three or four days. Jactitations of the stump are the rule and are often very violent during a bout of pain.

Cramp-like pain.—In this type of pain the phantom is felt to be rigid, the fingers or toes often appearing to be powerfully flexed, and the rigidity appears to cause the cramp-like pain. If the pain is relieved by any means the rigidity ceases with it. This sensation gives rise to such statements as "The doctor forgot to straighten my fingers before he took off my arm", but the position of the limb before operation is not a factor in the production of this sensation

Complex sensations.—Many peculiar sensations may be described: for example, the patient may feel blood running from a wound, be conscious of a fracture or feel that a toe-nail is being pulled off. Some, but not all, of these sensations are memories of the damaged limb before operation, and in that case if they are painful they are frequently felt immediately after operation, are of obsessional intensity and are very resistant to treatment.

Pain felt in the stump

Pain felt in the stump falls into one or more of the following four categories. It may be combined with pain in the phantom.

Pain associated directly with local abnormalities in the stump.—A badly fitting artificial limb, sepsis of the stump or deformity of the stump due to marked retraction of scars can cause pain. If the stump is not adequately exercised soon after operation

the joints become stiff and the muscles weak and the pain occurs when the stump is required to support the strain of an artificial limb. The skin may be tender if it passes directly over the end of the bone, but small spurs, which are commonly found on the cut end of bone, are rarely the cause of pain.

Aching, burning and shooting pains.—These pains correspond to the similar pains in the phantom and if localized are felt in the tip of the stump. In some cases the patient is uncertain whether the pain is in the stump itself or in the digits of a phantom so abbreviated that they are in or on the tip of the stump.

Pain associated with a cold and cyanosed stump.—The pain is continuous and accompanied by marked generalized tenderness of the stump, spreading in some patients to adjacent parts of the trunk. This type of pain is specially suitable for treatment by interruption of the sympathetic supply of the stump (Leriche, 1939), and is believed to be due to impulses from irritated neuromas or cut nerves causing reflex vasoconstriction which is itself painful.

Diffuse hyperaesthesia.—The skin of the stump is exquisitely sensitive to the lightest touch, but firm pressure is well tolerated. The mechanism of this pain is unknown, but Leriche has at operation in four cases of this type seen vasodilatation in the meninges and around the nerve roots. These cases are most intractable.

EXAMINATION

In severe cases the patient's drawn and haggard appearance reflects his sufferings, and the appearance of violent jactitations of the stump generally indicates that severe pain is being experienced. The stump should be examined to exclude sepsis or bruising. The scar should not be adherent to deep structures nor cause deformity of the stump by retraction. The following points require particular attention.

Neuromas

In spite of many ingenious manoeuvres designed to prevent their growth (Boldrey, 1943), neuromas, some of them very sensitive, develop at the end of cut main nerves, varying in diameter from a few millimetres to several centimetres. Pressure on them produces alterations in sensation generally referred to the phantom, and a neuroma may be found from which pressure will elicit the pain of which the patient complains. If operations have been performed on the nerves after the amputation, some of the neuromas may be difficult to locate and several may develop along the course of a previously excised nerve.

Circulation

If the stump is cold or cyanosed it should be determined whether it is constantly cold, and whether the stump circulation improves with warmth applied to other limbs as in the usual tests for peripheral vascular disease.

Cutaneous hyperaesthesia

Local.—The scar and its immediate vicinity may be very sensitive. Treatment by percussion or compression is indicated in these cases.

Diffuse.—Rarely the whole stump is exquisitely tender to light touch but firm pressure is well tolerated.

Psychological assessment

The patient's appearance may reflect the amount of pain he experiences or the amount of drugs he takes. The observer must attempt the hard task of assessing the amount of the patient's suffering and the effect of psychological factors on his disability.

TREATMENT

Preventive

As in the rehabilitation of patients with injury to a peripheral nerve, the convalescence of the amputee should be directed primarily in two directions.

Maintenance of morale and relief of anxiety.—The patient should have early diversional therapy, and plans should be made for his future, including if necessary training for a new occupation. The hospital almoner should advise both the patient and his relatives.

Maintenance of full movement of the stump.—The amputee must do exercises not only to maintain mobility of the stump but also to increase its power, since it will be required to control the artificial limb. In addition to supervised exercises he may be made to play with a large soft india-rubber ball which he can propel with his stump. This teaches him good control of the stump and shows him that it is not unduly sensitive. It should be clearly understood that if hyperaesthetic areas develop, the patient's instinct to protect them may have disastrous consequences as this attitude generally makes matters steadily worse. The early and vigorous use of a temporary artificial limb is the best counter to any tendency for pains to develop.

Curative

Every effort should be made to find and localize as accurately as possible all tender neuromas. Excision of neuromas has been practised extensively, but the pain often recurs soon after operation and subsequent operations have progressively less effect. All nervous tissue and especially neuromas can be rendered inactive by repeated trauma or compression: for example, compression only too easily prevents conduction in a nerve as in a crutch palsy, and the fingers may be rendered numb for many hours or days by certain occupations which involve prolonged forceful pressing or gripping with the fingers. Recent experience (Russell, 1949; Russell and Spalding, 1950) has shown that this fact can be exploited in the treatment of pain arising in amputation stumps. By repeated percussion or compression, neuromas can be rendered insensitive, and in most cases there is relief from spontaneous pain in the phantom or stump.

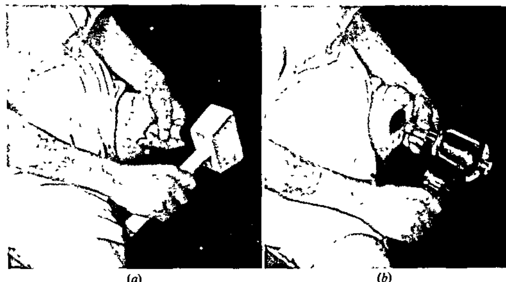
Percussion treatment

If the neuromas are very tender a sphygmomanometer cuff is applied to the proximal part of the stump and inflated to a pressure of 200 millimetres of mercury, or more if the patient is hypertensive. After some minutes the anoxaemia makes the neuromas insensitive and they can be percussed. The most suitable apparatus for this purpose is [illegible]

[illegible]

patient, however, will have sensations referred to the phantom or stump and these confirm that the applicator has been placed and has remained on the right spot. After percussion has been performed for several minutes the cuff may be removed, but percussion should be continued for 20 minutes in all. After the first treatment the cuff is not generally necessary but percussion should be repeated three or four times daily, and a treatment immediately before going to bed is useful as it may ensure a good night's rest. In favourable cases with well-localized superficial neuromas the pain is relieved within two minutes of beginning treatment and is replaced by a comfortable numbness, but often relief is not obtained until treatment has continued for perhaps ten days.

A vibrator may be used in place of the mallet and applicator (Fig. 1 *b*). Its effect is more diffuse, but it is less satisfactory than the mallet for small areas, and unlike the mallet the vibrator is liable to bruise the skin after prolonged use. It is useful for patients in whom it is difficult to localize the neuromas, but often in such patients after a few days' treatment with the vibrator the surrounding tenderness has subsided and it is possible to define precisely the place requiring treatment with the mallet.



(*a*) (*b*)

FIG 1.—Patient using (*a*) applicator and mallet for the treatment of painful phantom limb, and (*b*) mechanical vibrator.

Whenever possible the patient should be taught from the start to apply the treatment himself, and he soon becomes the best judge of the areas requiring treatment. After two or three weeks' treatment, during which the patient is encouraged to wear his artificial limb and busy himself with occupational therapy, the interval between treatment is gradually lengthened until once a day is sufficient. Finally the treatment may be reserved to "knock away the pain" when it is troublesome.

Treatment by percussion may also be used to treat tender scars on amputation stumps or elsewhere. Firm pressure on scars or on neuromas is often a most valuable additional line of attack and can assist in maintaining the relief of pain when this has been obtained by percussion.

Sympathectomy

In some cases the stump is cold and diffusely tender, and spontaneous pain is mainly referred to the stump. Such cases have generally had pain for many years and many operations on the stump, and may have no localized areas of tenderness to which percussion can be applied. These cases are especially suited for treatment by interruption of the sympathetic supply to the stump (Leriche, 1939). The appropriate part of the sympathetic chain is infiltrated with local anaesthetic and as the stump becomes warm the pain ceases. Sympathectomy may then be performed with good prospect of success, but since sympathetic infiltration with local anaesthetic may give relief for several months, some patients prefer to have repeated injections (Leriche, 1939). The same procedure is also sometimes effective in relieving pain felt in the phantom (Livingston, 1944).

Posterior root section

This procedure has met with some success but is very unreliable and the loss of sensation brings added troubles. For not only is loss of superficial sensation on the

stump dangerous, but loss of postural sense in it may make an artificial limb uncontrollable. Caudal anaesthesia gives temporary relief in some cases, and may be repeated on several occasions if the effects appear to be favourable.

Chordotomy

Section of the spino-thalamic tract in the spinal cord is sometimes successful in relieving pain in lower limb amputations, but is unsuitable for upper limb amputations. Such an operation should not be considered until treatment by percussion and by sympathetic interruption have been well tried, for relief of pain is by no means certain even if a satisfactory level of cutaneous analgesia is obtained. This uncertainty also applies to the results of mesencephalic tractotomy, which operation has been carried out for the relief of pain in the upper limb.

Cortical excision

A phantom limb has disappeared after a lesion of the opposite cerebral hemisphere (Head and Holmes, 1911), and on other occasions painful phantoms have become comfortable after focal epilepsy originating in the opposite hemisphere (Mahoney, 1944). Attempts have been made to turn this knowledge to account by excising an area of the post-central gyrus which is found by stimulation to correspond to the phantom limb.

This operation is of considerable physiological interest, for acute lesions of the sensory cortex cause temporary analgesia in the corresponding limbs, and may even permanently alter pain thresholds. There are, however, several difficulties. First, there is doubt as regards the amount of sensory cortex which should be removed; secondly, the resulting loss of postural sense in a lower limb case will increase difficulty with walking, and thirdly, when the dominant hemisphere is being operated on there is a risk of causing aphasia. Nevertheless, this operation may prove to have a small but useful place in the treatment of these cases.

Leucotomy (lobotomy)

Pre-frontal leucotomy has been performed for pain due to an amputation. It is very rarely justified owing to the serious change of personality which is likely to occur.

In some few cases where the pain has become severely obsessional, electric-convulsion therapy is worth considering.

CONCLUSION

In cases of pain following an amputation, as in other painful conditions, there are several lines of therapeutic approach, and to some extent the investigation of each case includes the trial of the various possible methods of treatment. Treatment by percussion gives excellent and often brilliant results in a large proportion of cases, is harmless and should be instituted from the first in all cases except those in which the circulation in the stump is defective. It is, however, best carried out at centres where many cases of amputation are treated so that the staff have sufficient experience to advise patients on the simple but important practical details of the method.

Pain arising in a stump in which the circulation is markedly impaired should be treated by interrupting the sympathetic nerve supply first with local anaesthetic and later if necessary by operation. This method should also be tried in the small proportion of cases on which treatment by percussion has little effect, and occasionally in refractory cases relief is obtained by interrupting the somatic nerve supply of the stump by spinal anaesthesia or prolonged epidural anaesthesia. It is often desirable to continue treatment by percussion while other methods are tried.

Only in the most obstinate cases in which these measures have failed shoulc operation on the central nervous system be considered.

(*See also British Surgical Practice:* Amputations, Vol. 1, page 178, S. Key 24; *and* Pain—causalgia Vol. 6, page 423, S. Key 256.)

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ANTIBIOTICS

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NATURE AND HISTORY

Antibiosis is the opposite of symbiosis, and may thus be defined as antagonism between one living thing and another, brought about by the formation of a noxious substance, the antibiotic. Although this term has been used of substances produced by higher plants and even by animals which have a very doubtful claim to antibiotic function in nature, it refers principally to products of fungi and bacteria. There are good reasons for believing that these products assist the organism forming them to eliminate other species in its environment, and thus to sustain itself in the competition for nutriment, particularly in a medium with a dense and varied microbic population, such as soil. It is possible that some such processes operate in the more bacterially crowded areas of the human body, notably the mouth and the lower bowel.

The existence of inter-microbic antagonism has been recognized for nearly 70 years, and attempts to exploit it therapeutically were also begun many years ago. These interesting early developments are well reviewed by Florey (1945). The preparations used were weak and grossly impure, and nothing was attempted beyond local application. The history of antibiotics as chemotherapeutic agents begins with the discovery by Dubos (1939) of gramicidin, now known as tyrothricin, formed by *Bacillus brevis*. Dubos concentrated and purified this substance, and showed that it had a curative effect on streptococcal and pneumococcal infections in mice when administered systemically. It is in fact too toxic for any but local use in man, but this proof that a substance of such origin could have a systemic anti-microbic action was a vital step towards later discoveries.

Penicillin, discovered by Fleming (1929), and shown by Florey and his colleagues (Abraham and others, 1941), who succeeded in extracting and concentrating it, to have the extraordinary powers we recognize today, was not only the first antibiotic to be used clinically as a chemotherapeutic agent but for some years the only one. There are now several others of almost equal merit, and a knowledge of their properties and indications is an indispensable asset in all branches of clinical work.

PENICILLIN

Theoretical considerations

Although the chemical structure of penicillin has been known for some years, it has not been found possible to produce it by synthesis: hence the drug is still obtained by extraction from cultures of the mould *Penicillium notatum*. The naturally formed substance is an acid, the salts of which, usually the sodium salt, are used in therapeutics on account of their greater stability. Although the main structure of the molecule is invariable, that of a side-chain differs with the conditions of production and can also be varied artificially. The chief natural penicillins, distinguished by the nature of this side-chain, are known as F, G, X and K; they differ in their degree of antibacterial activity and in their rate of elimination from the body. Penicillin G (benzylpenicillin), the properties of which are satisfactory on each of these counts, predominates in the commercial product of today.

As with all products of unknown or variable composition, it was desirable at an early stage to define a unit of activity. The International Standard adopted in 1945 was based on the original Oxford unit, and dosage has thus been measured in the same terms throughout the history of the drug. This unit is equivalent to 0·6 microgram of pure sodium penicillin G, and it would therefore now be possible to prescribe gravimetrically, but this is not the present practice and seems unlikely to become so.

Penicillin is available as a pure product (1,667 units per milligram), which is white and crystalline, or in a less highly purified form, having nevertheless nowadays an activity of 1,000 units per milligram or more, and yellow in colour.

If penicillin is swallowed, much of it is destroyed by gastric acid, and the degree of absorption of the remainder is variable. Although large doses by this route often have an effect equivalent to that of small doses by injection, an element of uncertainty remains, and for serious therapy the oral route is inadvisable. The alternative is parenteral injection, usually intramuscular, in watery solution: penicillin is so soluble that a large dose can thus be administered in a small volume. Absorption is rapid, the peak concentration in the blood being reached within 15 minutes after a moderate dose. Renal excretion is also unfortunately very rapid, and the blood level falls steeply at first, later rather more gradually. The drug passes into all body fluids except the cerebrospinal fluid, in which only traces appear. About 60 per cent is excreted in the urine, and a little in the bile and other secretions: the remainder is destroyed in the body. Penicillin is similarly, although more slowly, absorbed from body cavities: if, [illegible]

toxic to man. Whereas most chemotherapeutic agents are effective only when a substantial fraction of the toxic dose is given, or even in doses from which some toxic effect has to be risked, penicillin is subject to no such limitations. The ordinary dose can be multiplied a hundredfold without fear of harmful results. These are seen only in patients who have become sensitized, and are then rarely of a dangerous nature.

For each susceptible bacterial species there is a minimum concentration of penicillin which will inhibit its growth. Higher concentrations, under favourable conditions, are bactericidal. The optimal concentration for this lethal effect is about ten times the minimal for inhibiting growth. It is a unique property of penicillin that further increase in concentration beyond this point does not add to the effect, and may even considerably diminish it. Thus the optimal concentration for killing staphylococci is about 0·1 unit per millilitre; even a thirty-thousandfold increase does not accelerate this effect, and some strains are killed more slowly when the concentration is raised to only a comparatively moderate degree: other species showing this paradoxical "zone phenomenon" are *Streptococcus faecalis* and haemolytic streptococci of Lancefield groups B and C (Eagle and Musselman, 1948). In treating such infections it is therefore theoretically preferable to maintain a constant tissue concentration near the optimum, rather than to produce wide fluctuations by giving large doses at long intervals.

Penicillin attacks only multiplying bacteria, and in any bacterial population, whether *in vivo* or *in vitro*, there are a few dormant cells which consequently escape its effect. Bigger (1944) coined the name "persisters" for these cells, and advocates a system of intermittent treatment, similar in principle to tyndallization, aimed at eliminating them.

All chemotherapeutic agents are highly selective: a substance toxic to all micro-organisms, despite their varied metabolic habits, and at the same time sufficiently non-toxic to the human body, probably cannot exist. Penicillin is no exception, and it follows that only certain infections are susceptible to it. There is however this difference

between it and other chemotherapeutic agents: that owing to its extraordinary lack of toxicity very large multiples of the minimal effective dose can be given, such as to affect bacteria within a wide range of sensitivity. There is also a whole series of gradations of sensitivity among different species: the former custom of classing bacteria as simply "sensitive" or "resistant" is misleading in the light of present knowledge, and in view of the possible effects of the heavy dosage which is now not only feasible but almost commonplace. It has also to be remembered that although the concentration of the drug which can be maintained in the blood is strictly limited, that attained in the urine is much higher, as are those which can be produced by various methods of local application.

Classification of sensitivity

It is, therefore, worth while to recognize several degrees of sensitivity or resistance: the following classification (Garrod, 1950c) includes the main species of surgical interest as well as a few others.

Fully sensitive (inhibited by 0 005–0 05 unit per millilitre)—*Gonococcus*; *Meningococcus*; *Str. pyogenes*; *Str. viridans**; *Pneumococcus**; *Staphylococcus aureus**; *B. anthracis*; *Actinomyces israeli**, *Treponema pallidum*; Vincent's organisms; *Erysipelothrix rhusiopathiae*.

Less sensitive (inhibited by 0 1–0 5 unit per millilitre)—*Clostridia*; *Corynebacterium diphtheriae*; *Leptospira icterohaemorrhagiae*.

Moderately resistant (inhibited by 1–10 units per millilitre)—*Haemophilus influenzae*; *Str. faecalis*; *Proteus vulgaris*; *Salmonella typhi*

Highly resistant (inhibited only by > 50 units per millilitre)—*Mycobacterium tuberculosis*; *Shigella dysenteriae*; *Pseudomonas pyocyanea*; most other Gram-negative bacilli; yeast-like and some other fungi, most viruses

Practical penicillin therapeutics

It would be impossible to emphasize too strongly that consistently successful use of penicillin depends on making a bacteriological as well as a clinical diagnosis (when the former is not evident from the latter, as for example in gonorrhoea or carbuncle), and often on a determination of the sensitivity of the bacteria concerned to the drug. This is particularly desirable when the species concerned is one of which some strains are relatively resistant, *Staph. aureus* being the notable example of this. The results of such a test may decide for or against employing this treatment at all, and if for it may determine dosage.

Parenteral administration

The continuous intravenous drip of penicillin, although it has some theoretical and even practical advantages, is now rarely employed. If administration is to be by periodic intramuscular injections of an ordinary solution, dosage and intervals will depend, [illegible] views of the surgeon with [illegible] effect. The duration of a [illegible] wn, and it is also known from the work of Eagle and Musselman (1949) that bacteria exposed to but not killed by penicillin require several hours to recover and resume multiplication. On the basis of these findings it may be stated (Garrod, 1950b) that in treating a sensitive infection the following should be the intervals between doses of different magnitude if the effect is to be continuous—that is, if some degree of bacterial recovery is not to take place in the latter part of the interval between one dose and the next.

* Some strains may be less, or much less, sensitive.

25,000 units	– – –	3 hours
50,000 ,,	– – –	4 ,,
100,000 ,,	– – –	6 ,,
250,000 ,,	– – –	8 ,,
500,000 ,,	– – –	12 ,,

There is one ground on which it may appear justifiable to extend these intervals further. It was first shown by Florey, Turton and Duthie (1946) and has been confirmed experimentally by Ungar (1950) that penicillin remains detectable in exudates after it has ceased to be so in the blood. How far this factor operates may depend on the nature of the lesion and particularly on the rate of exudation into and of lymphatic absorption from it. It is perhaps unwise to regard this factor as justifying a further substantial addition to the inter-dose interval. In fact the intervals suggested above should probably not be exceeded in the treatment of any serious infection: in minor conditions, of course, it is permissible to employ systems which are admittedly below the optimum of efficiency.

When less sensitive infections are being treated, the higher blood and tissue concentrations required are attainable by either increasing the individual dose or shortening the interval, or both.

Repository preparations

Many efforts have been made to secure a prolonged effect from each dose of penicillin, thus obviating the need for frequent injections. Apart from drugs such as caronamide, which delay renal excretion and are chiefly indicated for sustaining very

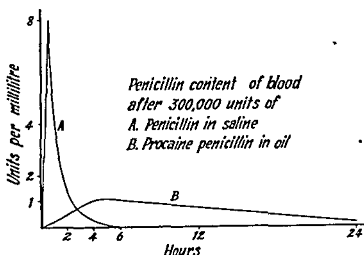


Fig. 2.—Absorption and elimination of penicillin preparations
(By courtesy of Brit. med. J.)

high blood levels, these efforts have been directed to delaying absorption from the site of injection. This can be achieved by suspending solid calcium penicillin in arachis oil containing 4·8 per cent of beeswax, but this base can produce undesirable local reactions. An important step forward was the introduction of procaine penicillin, an equimolecular compound of the two substances, much less soluble than penicillin, but equivalent to it in antibacterial potency. This can be suspended either in oil, or, if particle size is regulated, supplied as a powder for suspension in water: a dose of 300,000 units of a satisfactory preparation of this kind is absorbed and eliminated as

shown in Fig. 2, the effect persisting for 24 hours. If aluminium stearate is included ... effect for several days is possible ... ctice, where ... continuous ... rable. If the ... of Earle and Musselman (1948), ... r

hand, if for any reason high blood levels are required, sodium penicillin should be used.

Local application

Penicillin exerts a powerful local as well as a systemic effect, and, unlike the sulphonamides, retains its activity in the presence of pus. It may therefore with advantage be injected into closed foci of suppuration, which it may consequently sterilize. although subsequent surgical treatment may still be necessary. Examples are intrathecal injection in meningitis and the treatment of empyema and suppurative arthritis. Powders or solutions containing penicillin have been successfully used in the prevention or treatment of wound infection, although parenteral injection has largely replaced them. Penicillin cream is of great value in the control of infection in burns. Inhalation of a solution will for a time suppress bronchiectatic infection and so improve the prospects for lobectomy. Local treatment, of less surgical interest, is also possible in the eye, nose, mouth and throat.

Indications

This article deals rather with principles than with the details of therapeutics, and it would be out of place to present a full list of clinical indications, especially since the use of penicillin in particular conditions is dealt with where these are described. There are five main categories of surgical or quasi-surgical infections in which penicillin may be required on each of which a few remarks are necessary.

Haemolytic streptococcus infections

Str. pyogenes of Lancefield's Group A is invariably fully sensitive to penicillin. It follows that in cellulitis, erysipelas, otitis media and septicaemia, if due to this organism, a prompt response may be expected from ordinary doses properly administered. It is apt to be forgotten that these conditions usually respond almost equally well to sulphonamides. It is certainly quite justifiable to rely on the latter in milder cases and when the administration of penicillin may be inconvenient. The main advantage of penicillin over the sulphonamides for this purpose is the greater rapidity of its effect. Haemolytic streptococci of other Lancefield groups, which are uncommon causes of serious human infection, vary in their sensitivity: B and C, occasionally seen as causes of puerperal fever, are only slightly less sensitive than A. Group D streptococci, on the other hand, possess in this as in many other respects the characters of *Str. faecalis*, and are relatively much less sensitive. These organisms are sometimes found in suppurating wounds and in urinary tract infections.

Staphylococcal infections

Sulphonamides are of no great value in staphylococcal infections, which were consequently the field in which the clinical use of penicillin was first explored with such gratifying results. Osteomyelitis, severe carbuncle and staphylococcal septicaemia are strong indications for penicillin, but they do not always respond as they have in the past because a race of staphylococci resistant to the drug is becoming

increasingly prevalent. They appear at present to account for only about 5 per cent of infections in the population as a whole, but are commonly found in 50 per cent or more when cross-infection is going on among in-patients in hospitals (Barber, Hayhoe and Whitehead, 1949). Opinion is divided on whether infection due to these resistant organisms will respond to much larger doses of penicillin: the probability is that some at least will not. This question and others connected with abnormal resistance to chemotherapeutic agents generally is discussed by Garrod (1950a). It follows that the sensitivity of staphylococci to penicillin, at least from all serious cases, should be determined in the laboratory. The only efficient substitute for penicillin, when it fails for this reason, is aureomycin.

Gas gangrene

The three main toxigenic *Clostridia* responsible for gas gangrene are all moderately and uniformly sensitive to penicillin, whereas only one of them, *Cl. welchii*, is sensitive to sulphonamides. It would therefore be expected that penicillin should have some efficacy in this infection, and clinical experience, so far as it is available and can be assessed, appears to confirm this (Porritt and Cruickshank, 1950). Large doses are indicated on the basis of the respective sensitivities of the organisms concerned. The scale of dosage required may be calculated as at least ten times greater than in, for instance, streptococcal infections, and the extent of the tissue affected and the urgency of the condition may be taken to increase the requirement even further. Other forms of treatment, including the use of antitoxin, should not be neglected.

Urinary tract infections

Since about 60 per cent of penicillin administered by injection is excreted in the urine, it may readily be calculated that the concentration there attained will exceed 50 units per millilitre on only moderate dosage. This makes it possible to eliminate from the urinary tract bacteria which, owing to their degree of resistance, would be unaffected elsewhere in the body. The common causes of such infections which can thus be dealt with are staphylococci, streptococci and *Proteus vulgaris*. This treatment is more fully discussed in the chapter on Urinary Antiseptics (Vol. 8, page 418).

Venereal diseases

It is a remarkable fact that the organisms causing syphilis and gonorrhoea are more sensitive to penicillin than are any other species. A single dose of a good repository preparation will cure the average case of gonorrhoea. The extent of the longer course required in syphilis depends very much on the stage of the disease.

Prophylactic use

Penicillin has been extensively used in many different circumstances as a preventive of infection. Some of these uses are well justified and others unnecessary or even ill-advised. Experience in Normandy in 1944 and in other spheres since has left no doubt of its value in preventing infection in extensive and badly contaminated wounds: such patients should always have several days of parenteral treatment. It should also be used as a cover for operations carrying a serious risk of sepsis, or of its extension. Certain dental extractions and complicated labour may call for it. On the other hand, clean operations should not require it, nor should it be used indiscriminately to prevent post-operative lung complications: these occur in spite of it and are then due to penicillin-resistant bacteria. Penicillin alone is not a good preventive of infection complicating operations on the urinary tract: some organisms, notably *Ps. pyocyanea*, thrive on it. A sulphonamide should always be given in addition: particularly good results have been claimed for penicillin with sulphadiazine (Prince, 1946).

STREPTOMYCIN

Theoretical considerations

Streptomycin, first described by Schatz, Bugie and Waksman (1944) is derived from *Streptomyces griseus*, a soil actinomycete, and is of so complex a chemical structure that its synthesis is unlikely. It is basic in nature, and the three salts employed therapeutically have been the hydrochloride, sulphate and calcium chloride complex. It exists naturally in only one form, but there is one artificial derivative, dihydrostreptomycin, which was introduced and for a time preferred on account of its alleged lesser liability to cause toxic effects. The original unit defined in biological terms was found to be the equivalent of 1 microgram of the pure substance, and the drug is now, unlike penicillin, invariably prescribed by weight.

When streptomycin is swallowed very little is absorbed: nor is it destroyed, and it hence exerts an action throughout the alimentary tract. To obtain a systemic effect it must be given by intramuscular injection. Absorption is rather slower than that of penicillin, as is excretion: a single dose of, say, 1 gramme administered in solution in water, in which the drug is freely soluble, will provide a therapeutic concentration in the blood for eight hours or longer (Boxer and his colleagues, 1948). Its distribution in the body, apart from the impermeability of the alimentary mucosa, is similar to that of penicillin: very little reaches the cerebrospinal fluid, and excretion is mainly renal.

Streptomycin is not, like penicillin, free from serious toxic effects: dosage must be strictly regulated in order to avoid them. The prolonged administration of a dose of over 20 milligrams per kilogram (that is over 1 gramme daily to a 50-kilogram man) is liable to cause damage to the eighth nerve, vestibular function being first affected, and in more severe cases hearing (Davis, Anderson and Landy, 1948; Graf, 1949). The damage, if severe, is permanent. It has been produced deliberately in order to relieve Ménière's disease. Dihydrostreptomycin was at first supposed to be free from this disadvantage, but this claim is not borne out by further experience. There is, fortunately, no danger in giving large doses (for example, 3 grammes daily) for short periods such as a week: the vigorous treatment of acute infections is thus not precluded.

Streptomycin is strongly bactericidal: the higher the concentration the more rapid is the effect (Garrod, 1948). It is the only one of the main antibiotics which thus behaves like an ordinary germicide: penicillin has an optimal low concentration for bactericidal action, and aureomycin and Chloromycetin are only bacteriostatic. In high concentrations, such as can be attained by surface application or in the urine, a substantial mortality is caused *in vitro* within a few minutes, and sterility may be achieved within an hour. The concentrations attained in the blood and tissues are such as to kill even highly sensitive bacteria more slowly, but there are no good reasons for believing that the nature of the effect is different wherever it is exerted.

Streptomycin is fully bactericidal only in a nutritive medium, and thus superficially resembles penicillin in apparently acting onl [illegible]

different.

The sensitivity of different strains of most species to streptomycin is so variable that a detailed list embodying precise information cannot truthfully be drawn up. Infections for which the drug is used fall into three main categories, the sensitivity of which may broadly be described as follows.

(1) Tubercle bacilli which have had no previous contact with streptomycin are consistently highly sensitive, their growth being inhibited by 0.2 microgram per millilitre. (2) Most other infections for which the drug is useful are due to Gram-

negative bacilli, the majority of which are moderately or highly resistant to penicillin. The main genera concerned are *Bacterium*, *Salmonella*, *Shigella*, *Proteus*, *Pseudomonas*, *Haemophilus* and *Pasteurella*: most species of these are inhibited by between 0·1 and 10 micrograms per millilitre, although some, particularly *Pseudomonas*, may be less sensitive. (3) Streptomycin also has an action on some Gram-positive organisms which are normally sensitive to penicillin, although this is generally of a lower order. It has thus sometimes been used when penicillin has failed in staphylococcal or streptococcal infections: such organisms are often inhibited by 2–5 micrograms per millilitre, but some streptococci are much less sensitive.

It is the main drawback of streptomycin, and quite the most striking feature of its behaviour, that bacteria can acquire resistance to its action with astonishing rapidity. This appears to be due to the fact that in a large bacterial population, even of a highly sensitive species, there are often a few individual cells possessing exceptional resistance: these survive and multiply during exposure to the drug. The result is that unless treatment completely eliminates the infection, the remaining bacteria are quite unaffected by the drug: the degree of resistance acquired is such that concentrations many thousand times greater than that originally inhibiting growth are without effect. So far as is known, strains which have become resistant remain so indefinitely, whether in their original host or in anyone else infected from him. This change commonly occurs within a few days, and has been observed within one day of the start of treatment (Finland and his colleagues, 1946; Garrod, 1950a). In the meantime, of course, many bacteria have been killed and the course of the infection has usually been influenced favourably. Every species behaves in this way, including the tubercle bacillus, although the latter develops resistance more gradually and slowly, first exhibiting it after about one month or considerably later (Wolinsky, Reginster and Steenken, 1948). In a small proportion of cases, both of tuberculosis and of other infections, resistance fails to develop, despite bacterial survival.

A resistant population commonly contains a proportion of cells which have undergone a further change and become "dependent". These organisms will grow only in the presence of streptomycin, whether in culture or in the animal body: the ludicrous situation is thus reached that infected animals survive if left alone, but die if treated with the drug (Miller and Bohnhoff, 1947). In so far as such change occurs in the infected human body, further treatment can do positive harm. There is some suggestion in observations made on one patient by Spendlove and his colleagues (1948) that this may happen in tuberculosis.

Administration

Parenteral streptomycin therapy is accomplished by intramuscular injection, the drug being simply dissolved in water: owing to the more prolonged effect of each dose, devices to delay absorption or excretion, as employed with penicillin, are not necessary. For the short-term treatment of acute infections the total daily dose is from 1·5 to 3 grammes and the interval between doses should be not more than 12 hours, and may probably with advantage be only 6 in a severe infection. The effects of such treatment should be rapid, and it should not in any case be continued on this scale for more than 7 days, owing to the danger of eighth nerve damage.

It was this danger which led to the modification of systems of dosage for tuberculosis, in which treatment has to be much more prolonged. It is now a usual practice to give only a single daily dose of 1 gramme for most forms of this disease, and even less frequent administration than this has been found effective, both experimentally (Feldman, 1946) and clinically. It is obvious that such treatment cannot exert a continuous effect and one is prompted to ask what is the nature of the action of streptomycin on tubercle bacilli in the body. Concentrations attainable in the body do, in fact, kill tubercle bacilli in a nutritive medium *in vitro* fairly rapidly (Garrod, 1950d).

and it seems at least a tenable proposition that each dose kills a substantial proportion of the accessible and actively multiplying bacilli in the tissues: there is, of course, no effect on those contained in avascular areas, particularly in foci of caseation, whence further invasion of surrounding tissues will subsequently occur. This hypothesis, whether correct or not, is the only one which appears to account for the success of such widely varying systems of dosage, some involving intermissions of several days or even a week.

Indications

Tuberculosis

Much clinical evidence has been accumulated on the effect of streptomycin in different forms of tuberculosis, and little more than the underlying principles so illustrated can be discussed here. There can be no doubt that the effect of the drug is on the bacillus itself, and this can only be exerted if one can reach the other. The nature of the lesion, whether early, inflammatory and still vascular, or chronic and involving extensive caseation and fibrosis—or in the lungs, cavitation—is thus all-important. In general, the more recent and acute the process, the more striking is the effect, as in the miliary form of the disease, and the early stages of extensive lung involvement.

Streptomycin is valuable in more advanced and chronic disease mainly as an aid to surgery. It may so improve the condition of pulmonary disease for the time being as to render thoracoplasty feasible when formerly it was not so. In genito-urinary disease it will deal with outlying foci and bladder lesions if the main renal seat of infection is removed by nephrectomy or hemi-nephrectomy. It is useful in bone and joint and glandular tuberculosis under the same conditions. The use of streptomycin should thus be planned in conjunction with surgery, bearing in mind that only one course of treatment may have any value: acquired bacillary resistance may preclude further treatment in the future. How far the simultaneous administration of *p*-aminosalicylic acid will succeed in preventing this change in different forms of the disease has yet to be determined

Septicaemia, meningitis and pneumonia

Among the less common causes of septicaemia, complicating wound sepsis, otitis media, severe urinary tract infections or lesions of the intestinal tract, are *Bact. coli*, *Proteus vulgaris* and *Ps. pyocyanea* The same organisms occasionally cause meningitis, complicating trauma or otitis media, or resulting from contamination during spinal anaesthesia, simple lumbar puncture or the treatment of cranial lesions. Gram-negative bacilli which may cause pneumonia include *Bact. friedländeri* and *H. influenzae*. All these organisms are more or less insensitive to penicillin and usually sensitive to streptomycin. The sensitivities of the individual strain should be determined and treatment planned accordingly. Full intramuscular doses are required, and in meningitis 100 milligrams daily should be given intrathecally.

Urinary tract infections

Streptomycin is excreted in the urine in high concentrations which are rapidly bactericidal to almost all species causing urinary tract infections if they possess normal sensitivity. It is most important to determine this, since there are now many patients who have previously been treated with the drug and in consequence harbour organisms which are totally resistant to it. These are sometimes found even in patients who have had no such treatment: it must, therefore, be concluded that resistant strains are being disseminated in the population as a whole.

Streptomycin is only fully active in an alkaline medium; it is therefore imperative

to render the urine constantly alkaline before treatment is begun: that this has been achieved should be confirmed by testing the first specimen passed on waking in the morning. The aim of treatment should be to maintain a constant high concentration in the urine for the short period required to sterilize it: not less than 0 5 gramme 3 times a day should be given, and 3 days' treatment is ample in an uncomplicated infection. The urine is in fact usually sterile within 24 hours, and only 3 or 4 doses may achieve a cure, but continuation of the treatment for several days may perhaps be safer. In the presence of obstruction or calculi, treatment is likely to fail, and whenever infection persists it is almost always found that the organism has become totally resistant.

Action in the intestine

Apart from its use in intestinal infections, oral streptomycin has been extensively used to suppress the flora of the bowel generally before operations, particularly in the colon. For this purpose its administration should be begun not more than 2 days before the operation: otherwise bacterial resistance may already have been established, and peritonitis, should it unfortunately result, as in a fatal case reported by Spaulding and his colleagues (1949), will be unamenable to further chemotherapy. On the other hand, the administration of an insoluble sulphonamide, such as succinyl sulphathiazole (Sulfasuxidine), may with advantage be begun several days earlier.

Local application

Streptomycin can be used in many of the same ways as penicillin as a local application for its direct antiseptic effect. It can be injected intrathecally, applied to the eye, inhaled, instilled into the ear and applied to ulcers or wounds. In the latter it is particularly valuable when properly used in eliminating Gram-negative infection preparatory to skin grafting. A difference from penicillin is that it is comparatively useless when injected into pus-containing cavities such as an empyema: this is believed to be due to its relative inactivity in an acid medium, the *p*H of pus being often as low as 6·0.

It has to be remembered that surface application may cause sensitization. This is sometimes seen in nurses handling the drug, who develop an urticarial condition of the hands and face.

AUREOMYCIN AND CHLORAMPHENICOL (CHLOROMYCETIN)

These two newer antibiotics may conveniently be considered together, since they have many properties in common. They need also be considered only briefly, since comparatively few of the indications for them are surgical: their main importance is that they have provided effective treatment for typhus in all its forms, typhoid fever, undulant fever and certain virus diseases. Both, like streptomycin, are products of soil actinomycetes, aureomycin being formed by *Streptomyces aureofaciens* and Chloromycetin by *Streptomyces venezuelae*. The latter has now been synthesized, and in its synthetic form, which has the same therapeutic action as the natural, is known as chloramphenicol.

Pharmacology

These antibiotics are well absorbed from the alimentary tract, and are consequently given by the mouth. They are by no means completely absorbed, and exert marked effects on the intestinal flora, but ordinary doses produce therapeutic blood concentrations lasting for as long as 8 hours or more. They are excreted in the urine, from which varying amounts averaging about 25 per cent of the dose administered can be recovered. Aureomycin also penetrates into the cerebrospinal fluid

Both drugs are unsuitable for parenteral injection, Chloromycetin because of its low solubility and aureomycin because solutions of the hydrochloride, the compound used therapeutically, are highly acid. Aureomycin has been given intramuscularly, but this causes severe pain and absorption is slow: it can however be given intravenously in dilute buffered solution, the injection occupying 15 to 60 minutes. Aureomycin borate has been used for some forms of local application.

The usual dose of either is from 2 to 4 grammes daily divided into 3 or 4 individual doses. No serious toxic effects have been seen, except occasional cases of granulocytopenia due to Chloromycetin. The latter commonly causes anorexia, and aureomycin is liable to produce nausea, sometimes with vomiting, and diarrhoea.

Action on bacteria and species sensitivity

As judged by their *in vitro* behaviour, both substances appear to be purely bacteriostatic. The number of species of sensitive micro-organisms is very large, but the majority of these are concerned in diseases of no surgical interest. Among ordinary bacteria which may be involved in surgical infections, the various pyogenic cocci are fully sensitive to aureomycin and less so to Chloromycetin: Gram-negative bacilli with the exception of *Proteus* and *Ps. pyocyanea* are also usually sensitive to both drugs but rather more so to Chloromycetin (as exemplified in its superior action in typhoid fever). Some degree of bacterial resistance to both drugs can be acquired, but it develops gradually and is never extreme.

Indications

As already stated, the main indications for these drugs are medical: some of their surgical uses are as follows *Penicillin-resistant staphylococcal infections* of all kinds can be successfully treated with aureomycin, to which this organism appears invariably to be sensitive. this promises to be a wide field of use as the proportion of strains resistant to penicillin steadily increases. Aureomycin, which has the largest range of activity of any of the antibiotics, is likely to be extensively used in the future in the treatment of *pneumonia* and post-operative lung infections generally, since all recognized microbic agents in these conditions are sensitive to it (Herrell, 1949). Aureomycin is also effective in all forms of *venereal disease*: its action in lymphogranuloma inguinale (Wright and his colleagues, 1948) and non-specific urethritis (Willcox and Findlay, 1949) is likely to be particularly valuable. That in syphilis remains to be explored more fully: for gonorrhoea Chloromycetin is likely to be preferred should a substitute for penicillin be needed, since this drug has less action on *Tr. pallidum*, and the masking of syphilis can thus be avoided.

Both drugs can be used in *urinary tract infections*: all organisms causing these except *Proteus* and usually *Ps. pyocyanea* are sensitive to either. Their relative merits for the purpose have not yet been fully assessed but aureomycin is the more widely used (Wilhelm and his colleagues, 1949; Rütenburg and Schweinburg, 1949). Chloromycetin is to be preferred for systemic infections such as *septicaemia*, due to coliform bacilli resistant to streptomycin. Aureomycin is said by Wright and his colleagues (1949) and by Yeager, Byerly and Holbrook (1949) and others to be highly effective in *peritonitis*. It is also claimed by Dearing and Heilman (1950) to be the most effective agent known for suppressing the intestinal flora. Neither of these drugs has any action in tuberculosis

Several further antibiotics of similar origin and properties have recently been discovered, of which terramycin (Herrell and his colleagues, 1950) seems the most promising.

ANTIBIOTICS FROM *BACILLI*

Among numerous other sources of antibiotics now recognized, the *Bacilli* (that is Gram-positive aerobic spore-bearers) have claimed the largest share of attention.

The first of these antibiotics to be shown to possess full chemotherapeutic activity gramicidin, now known as tyrothricin, was in a sense the forerunner of penicillin since Florey acknowledges that the work of Dubos in this connexion persuaded him to explore the possibilities of penicillin from the same point of view. Tyrothricin although capable of curing certain infections in animals, is too toxic for clinical parenteral use: it is used as a local application to wounds and mucous surfaces.

Substances more recently isolated from organisms of this genus include bacitracin the polymyxins, subtilin, licheniformin and several others. All are polypeptides, and have a high degree of activity against many other species of bacteria, notably Gram-negative bacilli, and including the tubercle bacillus: their action is bactericidal. The property which has prevented their general adoption as chemotherapeutic agents is toxicity, particularly for the kidney: they are liable to produce degenerative tubular changes accompanied by albuminuria, resulting sometimes in anuria and death. The degree of this tendency varies even among the polymyxins (related substances derived from *Bacillus polymyxa*), and it seems possible that a product may be evolved of which *the use, at least for certain indications, may be justified. One such indication will then* certainly be severe infections by *Ps. pyocyanea*, which is usually highly sensitive to antibiotics of this class and often resistant to all others. Bacitracin has thus been used on a limited scale in the United States of America, and its advocates are convinced of its value. The fact that indications for this class of antibiotic are so strictly limited when all factors, including toxicity, are considered, accounts for their commercial non-availability.

See also British Surgical Practice · Asepsis and Antisepsis, Vol 1, page 433, S. Key 41 ; *and* Urinary Antiseptics, Vol. 8, page 418, S. Key 338.)

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APPENDICITIS AND PERITONITIS

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APPENDICITIS

It is a pleasing reflection that the mortality [illegible] steady decline over the last ten years for which the [illegible] (Fig. 3). It will be noted that during this de[illegible] having fallen almost consistently from 3,027 deaths in 1938 to 1,491 deaths in 1947, and it can be hopefully presumed that this decline in mortality will continue. It is interesting to note that during the worst years of World War II (1941–1944), no

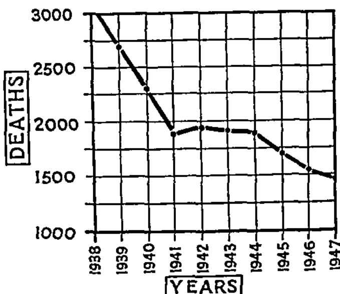


Fig. 3.—Mortality from acute appendicitis, 1938–1947.

appreciable diminution in mortality occurred. This was no doubt due to the evacuation of children to remote areas and depletion in the number of civilian doctors owing to the demands of the services.

The decline in mortality is mainly due to the following factors: (1) The older generation who prescribed castor oil for abdominal pain is extinct, and most parents are now wise enough to eschew purgatives and to summon medical aid if a child is afflicted with pain and vomiting. (2) Refinements of anaesthesia and the diminution of post-operative complications assist in reducing the mortality of operations for acute appendicitis, as in other branches of surgery. (3) Chemotherapy is valuable in cases of acute appendicitis as in other infections. Oral administration of sulphonamides may be precluded by vomiting, or contra-indicated during expectant treatment, in which case soluble preparations are given intramuscularly, or added to an intravenous drip if one is in use. Furthermore, during the operation of appendicectomy the local application of sulphonamide is indicated if there is any likelihood of peritoneal contamination (*see* page 38). (4) There is greater discrimination in selecting the time for operation.

In the early years of the surgery of the appendix it was taught and practised that an acutely inflamed appendix should be removed as speedily as possible. Subsequently, greater faith was placed in the ability of the peritoneum to overcome infection, and of the omentum and adjacent structures to limit the spread of inflammation.

Treatment

All agree that appendicectomy is urgently required when acute inflammation is limited to the appendix. It is the cases which present themselves with three or more days' history and an indefinite mass which cause contention. Since that time, nearly fifty years ago, when Oschner recommended starvation and avoidance of aperients, other additional measures have been introduced which are a comfort to the patient and which have strengthened the hand of the surgeon who practises expectant treatment.

Thus, by means of intravenous infusion, the patient is relieved of thirst, fluid balance can be maintained and chloride depletion prevented. In addition, penicillin and the sulphonamides are useful in this as in other acute infections, and can be administered parenterally. Anti-gas-gangrene serum, which was formerly popular, has now been replaced by penicillin. With these adjuvants to expectant treatment over 90 per cent of cases of localized peritonitis resolve, to enjoy a safe and simple appendicectomy three months later. The majority of the remainder form a localized abscess which is dealt with on its merits, while in a very small minority the inflammation extends.

Criticisms of expectant treatment

Patients may not co-operate.—If a patient has successfully weathered the storm of a local peritonitis he may be unwilling to return for appendicectomy three months later. However, unless he is submental, a few words of explanation convince the patient that he has survived a serious illness which is liable to recur, and that a safe and simple operation will guarantee cure.

Expediency.—Whatever treatment is adopted in dealing with a case of localized peritonitis, a small mortality is to be expected. If a case treated on expectant lines ends fatally it is regarded as a tragedy, but if an immediate attempt is made to remove the appendix the general impression is that, because active treatment was adopted, everything possible was done and the tragedy is accepted philosophically. Berry (1922), referring to cases of localized peritonitis, summarized the position thus: "I shall probably be told I am trying to put the clock back. I maintain on the contrary that I am trying to introduce a little more sanity into present-day treatment, a little more discrimination and judgment in the choice of operation and when and how it should be performed, a little less reliance on the hard-and-fast rule adopted by so many of operating at any and all stages—a rule so easy to follow but so often so disastrous to the patient."

Experienced surgeons publish personal statistics showing a low mortality with immediate operation. Their matured skill enables them to operate with extreme delicacy and balanced judgment. But, from the practical point of view, it is the less experienced surgeon who operates on the majority of cases, and if his task can be simplified patients will reap the benefit. It requires little experience to decide whether the pulse rate is rising, whether a swelling is enlarging, or whether a zone of tenderness is increasing. As the majority of cases treated expectantly subside, the number of difficult emergency operations is correspondingly reduced and most of these merely require a drainage tube.

On the other hand, if immediate operation is undertaken, removal of the appendix in cases of localized peritonitis or abscess formation is usually difficult or even

impossible. Unless the appendix happily presents itself, searching for the organ is liable to separate protective adhesions and spread infection, which increases toxic absorption and may convert a localized into a generalized peritonitis. Congestion and friability of tissues add to the difficulties of the operation, especially invagination of the appendix stump, and the insertion of a drainage tube, with its attendant disadvantages, is usually necessary.

As Wilkie (1932) stated, "If a surgeon blunders in, breaks down adhesions and causes haemorrhage, obstructive complications not infrequently supervene. Honesty on reflection will bring to the minds of most surgeons cases of this order which they would willingly forget."

Mistaken diagnosis.—Expectant treatment is adopted only if the diagnosis of acute appendicitis is made with confidence. As surgery is an art rather than a science, an occasional error may occur, even though such investigations as examination of the urine, radiological examination of the abdomen and blood tests are carried out in order to differentiate appendicitis from other conditions.

However, delay in connexion with an erroneous diagnosis may be a blessing in disguise, as conditions which are unsuitable for operation may reveal their true nature after a short period of delay. Zachary Cope (1936) aptly sums up the matter as follows: "Delay in mistaken diagnosis is counterbalanced by the risk of operating on cases which are unsuitable, and which would be diagnosable by progress—e.g. salpingitis, cyclical vomiting and chest conditions."

Technique of expectant treatment

As a general rule expectant treatment is not suitable for children under the age of 10 years, or for elderly patients. In children the omentum is short and flimsy and resistance to infection is diminished at the extremes of life.

Briefly, expectant treatment is conducted as follows.

Position.—The patient should be propped up comfortably in bed. As no free fluid is present Fowler's position is unnecessary, although the patient may find a modified Fowler's position comfortable.

Charts.—A 2-hourly or 4-hourly record is kept of the temperature and pulse. If, or as soon as, the outline of the mass can be determined, it is recorded diagrammatically on the chart (Fig 4). Vomiting is duly noted and the quantity and nature of the vomit is observed.

Local applications.—Warmth is comforting to the patient, and may be applied by an electric pillow or a kaolin poultice.

Diet.—No fluid or food of any kind is permitted by the mouth until the pulse and temperature are satisfactory, which is usually from the fourth to the sixth day. Prior to the introduction of intravenous infusions, this imposed a great hardship on the patient, and, on humane grounds, small quantities of water were permitted by the mouth or a limited amount of fluid was introduced rectally. Both of these measures encourage peristalsis and are consequently harmful. In intravenous therapy we have a potent weapon added to the armamentarium of delayed treatment, and one which further improves the prospects of success when this method is adopted. Saline solution and glucose are administered as required, and a balance sheet of fluid output and intake is recorded so that an adequate amount of fluid can be administered and the risk of pulmonary oedema avoided.

When it is considered safe to permit intake by the mouth, small feeds of milky food, such as Horlick's Malted Milk or Benger's Food, are well tolerated. Meat extracts, fruit drinks, custard and sieved stewed fruit are gradually added to the diet.

Mouth washes are administered freely from the beginning of the illness. In addition to the usual medicated preparations, aerated fruit drinks, pineapple juice

or lager beer are appreciated by individual patients, and all encourage salivary secretion.

Bowels.—The bowels are ignored unless natural evacuation occurs, but a flatus tube is permissible as distension may thereby be relieved. After the acute phase has subsided—usually towards the end of the first week—a small (3-ounce) glycerin enema is given, and subsequently liquid paraffin, half an ounce night and morning, is prescribed. When the pulse and temperature have been normal for a week, some aperient, such as cascara evacuant or one especially favoured by the patient, is useful in order to reinforce the action of the liquid paraffin.



Fig 4.—Chart showing outline of mass, temperature and pulse rate.
(*By courtesy of H. K. Lewis*)

Drugs.—It is a golden rule that, pending a decision whether or not to operate on an abdominal case, no sedative of any kind should be administered. In cases such as those under discussion, actual pain as opposed to tenderness is not a marked feature.

definite decision has been made that delayed treatment is advisable, one moderate dose of Omnopon is beneficial in encouraging rest during the first night in strange surroundings.

Results of delayed treatment

Inflammation gradually subsides and rigidity and swelling gradually disappear. Before the advent of antibiotics and intravenous drip about 70 per cent of cases of local peritonitis subsided, but with the addition of these valuable advances in treatment this figure has risen to 90 per cent. As previously stated, the appendix is removed three months later. The operation is a clean one, the mortality negligible and the freedom from adhesions is usually remarkable.

The second possibility is that an abscess may form around the appendix. In such cases the diffuse swelling gradually becomes more localized until a firm and tender mass is palpable. Although resolution is the ideal termination of expectant treatment, the formation of an abscess is welcomed in that it is an indication that the resistance

of the patient has arrested the spread of infection. As Rayner (1933) stated, ". . . if the mass becomes converted into an abscess the patient has gained rather than lost by the delay". If an abscess develops, delayed treatment is continued, and it is useful to outline the limits of the abscess on the abdominal wall with a silver stick so that its extension or recession can be visualized from day to day.

In the majority of cases the abscess responds to delayed treatment. The patient's general condition gradually returns to normal, while the abscess becomes firmer and tenderness diminishes. As a rule the swelling disappears by about the third week of the illness, but in the following circumstances drainage of the abscess is usually advisable.

(a) If the abscess increases in size it is drained to avoid the possibility of rupture into the general peritoneal cavity. Usually an abscess discharges itself into adjacent bowel, but it is unwise to await this natural method of relief. Tenesmus and the passage of mucus are common symptoms of a pelvic abscess.

(b) If there is redness and oedema of the parietes, especially if fluctuation is detected, the abscess is likely to discharge through the abdominal wall. A surgical incision shortens the process and heals more readily than does a spontaneous opening.

(c) If there is a rising pulse rate, which is more significant than elevation of the temperature and indicates that toxaemia is increasing as a result of extension of inflammation. If the pulse rate is increased or even stationary after the expiration of twenty-four hours it may be wise to abandon delayed treatment.

(d) If pain is increasing, especially when associated with an extending area of tenderness.

(e) If there is persistent vomiting, or increasing gastric secretion after a Ryle's tube has been passed into the stomach.

Operation on a localized mass necessitates judgment and gentleness. Rutherford Morison's incision (*see British Surgical Practice*, Vol. 1, page 310) is often advisable, as it approaches the infected area from the flank. A prolonged search for the appendix is unjustifiable, and in many cases drainage only is advisable.

GENERAL PERITONITIS

General peritonitis accounts for more than half the mortality attributable to acute appendicitis. Fortunately this dreaded complication, so common even only a quarter of a century ago, is now but seldom seen, owing to improvements in treatment already outlined.

If the condition of the patient is satisfactory appendicectomy should be performed forthwith. However, a delay of a few hours, during which time gastric aspiration, [illegible] the state of the [illegible] ɔpon, will relieve the patient's anxiety.

It is especially in profoundly toxic patients that delay is imperative, the more so if, as is commonly the case, abdominal distension or tympanites is present. It is agreed that most cases of ascitic tuberculous peritonitis respond to laparotomy. The explanation is that the intra-abdominal tension is thereby reduced, so that lymphatic and vascular channels are able to dilate, and the improved circulation has a beneficial influence on the disease. In cases of general peritonitis and distension, sudden decompression of the abdomen by laparotomy produces a similar physiological effect, that is, rapid acceleration of lymphatic and venous drainage. But the pathological result in this case is that the circulation is rapidly flooded with toxins, usually at the time when the patient's resistance is feeble. Post-operative collapse and death within a few hours was a common sequel, the condition, which was in reality acute toxaemia, being euphemistically designated as "shock".

The management of late general peritonitis is conducted on lines similar to those described for patients with local peritonitis, and the case terminates in one of the following ways.

Resolution of inflammation.—The pulse rate steadily falls, gastric aspiration indicates diminished secretion, and the abdomen becomes softer and less tender. Passage of flatus indicates that peristalsis is returning, and is an eagerly awaited sign. The patient returns for appendicectomy three months later.

Improvement followed by appendicectomy.—Signs of acute toxaemia gradually lessen, and this improvement affords the surgeon the opportunity of removing the appendix, especially in patients who are constitutionally unfitted to withstand toxic absorption for more than a minimal period, for example, children and the aged.

Localization and abscess formation.—In cases which are obviously improving delay is usually advisable in the hope that resolution will occur or that the inflammation will localize with the formation of an abscess. Suitable drainage can then be safely employed if and when such a procedure is considered advisable.

No response to treatment.—A small minority of patients fail to respond to any treatment. The pulse rises while the volume falls, gastric or intestinal aspiration produces foul, brownish fluid in increasing amounts and the abdomen becomes tympanitic. The facies hippocratica portends the end.

Sir James Paterson Ross (1936) quotes two typical cases of this nature, one of which was operated upon within six hours and the other within twelve hours of the onset of the attack. Both died between the third and fourth day without showing any attempt on the part of the peritoneum to localize the infection. Every experienced surgeon has met with similar cases and will agree with Paterson Ross who states, "there must always be a mortality from appendicitis because of the occasional failure of the peritoneum to respond to infection".

Operation

Closure of grid-iron incision.—Careful attention should be given to this procedure, and common flaws in technique are depicted in Fig. 5. After suture of the peritoneum a catgut stitch is inserted through the muscles, and should be utilized to lift the

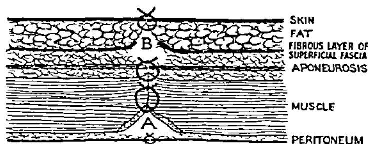


Fig. 5 [illegible] "dead" spaces in which exudates collect, with risk of subsequent infection

muscles from the subjacent peritoneum so that subsequent sutures can safely be inserted through the whole thickness of the transversalis and internal oblique. The external oblique aponeurosis is then approximated with a continuous suture, care being taken to avoid inclusion of any fibres of the internal oblique muscle. The function of the aponeurosis, which is a flat tendon, is to slide over the deeper muscle,

and if it is anchored at any point the patient complains of "stitch" or localized discomfort until the catgut absorbs some two or three weeks later. The skin and deep fascia are approximated with interrupted sutures. Care should be taken to include the deep fibrous layer of the superficial fascia with each stitch, otherwise a broad and unsightly scar is the ultimate and inevitable result. This is a permanent reproach to the surgeon, and proclaims that he did not appreciate the fact that the deep fibrous layer of the superficial fascia protects the skin from undue stretching (an oversight also commonly revealed after operations for inguinal hernia). For this reason the use of Michel's clips to approximate the skin edges is to be deprecated, unless the subcutaneous tissue and the already mentioned fascia are previously sutured.

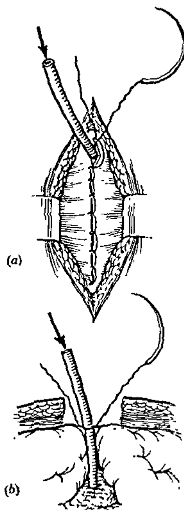


FIG. 6—(a) Injection of sulphonamide suspension into the peritoneal cavity, (b) the suspension diffuses around the structures in the infected area.

Intraperitoneal use of sulphonamides

Dumping half a teaspoonful of sulphonamide powder into the peritoneal cavity provokes adhesions and has the additional disadvantage that diffusion of the powder into all the recesses of the cavity is very unlikely. One excellent preparation for local sulphonamide therapy is Mickraform. This is a 20 per cent crystalloid sulphathiazole suspension, so 5 millilitres contain 1 gramme of sulphathiazole. The size of the crystals is minute as compared with the ordinary sulphathiazole crystals, and therefore they cause no damage to the delicate endothelial cells. If considered advisable it can be diluted with normal saline solution to any required strength. In any case, if the solution is poured into the wound before closure a variable amount trickles out again before the suture can be completed. A simple manoeuvre will prevent the waste of this unknown quantity and give the surgeon the satisfaction of knowing that the amount of drug which he wishes to use is actually retained. This manoeuvre consists in the introduction of a rubber drainage tube of small calibre down to the selected site. The peritoneum is then closed with a continuous suture, the last loop of which encircles the tube without compressing it (Fig. 6). The sulphathiazole suspension is then injected down the tube with any suitable syringe and, as the tube is withdrawn, the suture is tightened and tied; escape of any of the fluid is thus prevented.

(*See also British Surgical Practice* Appendicitis, acute, Vol 1, page 293, S. Key 35; *and* Peritoneum and Peritonitis, Vol 6, page 544, S. Key 264.)

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AUTONOMIC NERVOUS SYSTEM—ANATOMY

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INTRODUCTION

It is assumed that the reader possesses the essential preliminary knowledge of the basic arrangement, embryology and physiology of the autonomic nervous system, so these are not discussed, and certain important facts already given in the first edition of *British Surgical Practice* are not repeated in this article. Attention is concentrated on those nerves described inadequately or inaccurately in standard text-books, and these include most of the sympathetic nerves. Certain others, such as many of the cranial parasympathetic nerves which are well described, and which in any case are *often of less practical importance from the surgical viewpoint, are merely mentioned.* Throughout the commonly accepted terminology is adhered to, and when the modern anatomical nomenclature used varies from that familiar to most surgeons the alternative term is given in parenthesis when the structure is first mentioned.

Definition and extent of the autonomic nervous system

The autonomic nervous system may be defined as the part regulating all those bodily processes which are not under voluntary or volitional control, with the probable exception of activities such as postural tonus. It consists of central and peripheral parts. The central elements are intrinsic parts of the central nervous system, being located in the cerebral cortex, hypothalamus, brain-stem and cord, and being interconnected by various tracts. The peripheral part consists of two paravertebral gangliонated trunks, and various pre-vertebral and visceral nerve plexuses and their branches in the neck, thorax and abdomen, in addition to autonomic fibres which are inherent constituents of most cerebrospinal nerves.

THE AUTONOMIC HIGHER CENTRES

Cerebral and cerebellar centres

Evidence is accumulating that there is a cortical autonomic representation in the premotor cortex, at scattered points in the motor area, and in the medial frontal and cingulate gyri. The location of these centres in the frontal lobes explains why various operative procedures and pathological conditions involving these lobes are associated with autonomic disturbances, although it should be mentioned that some of the results following frontal leucotomy or lobotomy have been attributed by some authorities to the severance of the uncinate association fasciculus between the frontal and temporal lobes, rather than to interruption of fronto-thalamic circuits. When the centres and their connexions are located more precisely in man, operations upon them will displace some of the less satisfactory peripheral sympathectomies, and doubtless new operations will be devised for the treatment of conditions at present unresponsive to surgical intervention or regarded as outside its scope.

Other autonomic centres may exist in the anterior lobe of the cerebellum, but information about them in man is minimal.

Hypothalamic centres

At least eight pairs of nuclei have been described in the parts of the hypothalamus which form the antero-inferior boundaries of the lateral walls of the third ventricle. Their exact functions and interconnexions are still imperfectly understood, yet as a result of animal experiments and clinical and pathological studies, certain information is available. Thus it is known that the supra-optic nuclei lying above and behind the optic chiasma send numerous fibres to the posterior lobe of the hypophysis (pituitary gland) and that interruption of these fibres produces diabetes insipidus; stimulation experiments tend to show that the posterior hypothalamic nuclei are concerned with sympathetic activity and the lateral hypothalamic nuclei with parasympathetic activity, although there is some overlap in the boundary zones. It is also known that the mamillary nuclei are relay stations on the pathways connecting the hippocampus and thalamus, and that the hypothalamus is of importance in regulating body-temperature, the sleep–waking and oestrus rhythms, and in controlling water, fat and carbohydrate metabolism. Together with the closely related hypophysis, the hypothalamus acts as a complex neuroglandular mechanism controlling functions of supreme and vital importance.

Centres in brain-stem and cord

The autonomic centres in the brain-stem are located in the mid-brain, pons and medulla oblongata, in close association with the nuclei of the third, fifth, seventh, ninth, tenth and eleventh cranial nerves, and it is believed that other nuclei in the reticular formation are also involved. Thus the respiratory centre is located in the medullary formatio reticularis adjacent to the olivary nucleus, and the circulatory centre [illegible] and extend for a short distance into the [illegible]

carbohydrate metabolism and sweat secretion have also been described in the medulla, but their limits have not been determined accurately and perhaps these and other centres are not confined to one anatomical nucleus but are represented by a group of intimately connected nuclei.

In the spinal cord the cells (intermedio-lateral) in the lateral cell columns are associated with autonomic functions. These columns are most prominent in all the thoracic and the upper two lumbar segments, and to a lesser degree in the second to fourth sacral segments, where the cells are more ventral. Scanty collections of similar cells are often detectable in the same position in other spinal segments, and it is said that in subjects with pre-fixation or post-fixation of the great limb plexuses a corresponding rostral or caudal shift occurs in the situation of the main parts of the lateral columns. The constituent cells are intercalary neurones, uniting afferent and efferent units in the reflex arcs, and forming other synapses with neurones of projection, association and commissural type through which they are influenced by impulses from other sources. Their fibres emerge in the great thoraco-lumbar sympathetic outflow and in the small sacral parasympathetic outflow.

Other groups of nerve cells which are, perhaps, associated with the autonomic system have been described in the intermedio-medial cell columns throughout the cord, and in the ventral horns of grey matter in the upper cervical and sacral regions.

Interconnexions between autonomic centres

Our knowledge of the various pathways interconnecting these centres in the brain and cord is relatively meagre and sometimes of doubtful reliability. The

information has been obtained from animal experiments, and in man from studies of retrograde degeneration following leucotomy operations and clinical investigations of patients who have had autonomic pathways destroyed by surgical or chemical means.

As a result of such observations it is now believed that there is an intimate two-way relationship between various frontal cortical areas and the hypothalamus. Until comparatively recently the greater parts of the frontal lobes were regarded as predominantly association areas, receiving and integrating impulses from other cortical areas and acting, so to speak, in the capacity of overlord. Phylogenetically, however, the frontal lobes have undergone less enlargement than the parietal or temporal lobes, and relatively they possess no preponderance either of long or of short association pathways; these facts do not support the assumption of their predominance in the highest mental processes, although they do not disprove their reputed role in the integration of those reactions and emotions which mould personality. It is probable that a considerable part of the frontal cortex is an afferent projection area for the hypothalamus, comparable with other afferent projection areas such as the visual or the auditory areas.

The hypothalamus is interconnected with the frontal lobes by two-way connexions, which may be direct, or more often indirect and through the thalamus. Thus fibres interconnecting the hypothalamus with the medial and inferior frontal gyri relay in the homolateral medial (dorso-medial) thalamic nucleus, and others connecting the hypothalamic mamillary nuclei with the cingulate gyri relay in the anterior thalamic nuclei, and lie in the mamillo-thalamic tracts of Vicq d'Azyr.

The hypothalamus is also interconnected with the rhinencephalon *via* the medial forebrain bundle, with the homolateral globus pallidus of the lenticular nucleus, which represents the palaeostriatum, through the ansa and fasciculus lenticularis; with the amygdaloid nuclei in the temporal lobes by the striae terminales (semicirculares), and with various nuclei in the brain-stem, such as those subserving taste, salivation and centres controlling circulation and respiration.

The close interconnexion between the hypothalamic supra-optic nucleus and the hypophysis has already been mentioned, as has the belief that closely integrated centres controlling water and carbohydrate metabolism exist both in the hypothalamus and medulla, although some workers claim that disturbances in carbohydrate metabolism, following various experiments on the medulla, are produced by damage to descending tracts from the hypothalamus and not to interference with separate centres in the medulla.

Efferent pathways

Even in animals the exact locations of autonomic tracts descending from higher levels to the brain-stem and cord are not accurately known. Some are supposed to lie in the medial longitudinal bundles which interconnect the various cranial nerve nuclei and which extend upwards to the hypothalamus and downwards to become continuous with the anterior intersegmental fasciculi of the spinal cord. Through these connexions autonomic fibres originating in the hypothalamus reputedly descend through the brain stem and anterior white columns of the cord as far as the upper lumbar segments. Other descending fibres may lie more laterally in the brain-stem, although their precise course is unknown, and still others may run in the small posterior longitudinal bundle of Schultze which lies close to the floor of the fourth ventricle. From the mamillary bodies the mamillo-tegmental tract is continued to the mid-brain, and so-called periventricular fibres connect the posterior part of the hypothalamus and the brain-stem. It will be evident that our knowledge of efferent or descending pathways between the cortex, hypothalamus, brain-stem and cord is speculative and very incomplete.

Afferent pathways

The location of afferent or ascending autonomic pathways within the central nervous system is less vague. Autonomic sensory fibres, like somatic fibres, have their cell stations in dorsal spinal nerve root ganglia, and in the ganglia connected with the roots of various cranial nerves. The peripheral parts of the axons, which resemble somatic afferent fibres in appearance and conduction rates, terminate in endings of various types—free, bulbous, brush, corpuscular, grape and so on—in the structures innervated, but the adequate stimuli for autonomic and somatic endings often differ in type or degree. These visceral afferents frequently travel for considerable distances through autonomic nerves, plexuses and the sympathetic trunks before passing through rami communicantes to adjacent spinal nerves and so to the cord; those from vessels, muscles, joints and other structures in the head and neck, parietes and limbs form integral parts of various cranial and all spinal nerves. The central processes of the axons enter the brain-stem or cord through these nerves, there to form synapses with intercalary neurones located in the same or adjacent segments, or at higher levels.

Somatic afferents concerned with the transmission of painful, thermal, pressure and protopathic tactile stimuli relay in the posterior columns of spinal grey matter, and it is believed that a proportion at least of the visceral afferents also form synapses with cells in or near these columns. If abnormal impulses from inflamed, distended or ischaemic viscera are transmitted through the visceral afferents the excessive stimulation may disturb the common pool of secondary somatic and autonomic afferent neurones in the posterior columns, setting up a so-called "irritable focus". In consequence visceral stimuli which normally do not produce conscious sensations may become appreciated because the threshold to pain may be lowered, and viscero-cutaneous and viscero-motor reflexes are facilitated. On this basis it is possible to explain why visceral disturbances may produce painful or other sensations and why they may be associated with muscle guarding and referred pain.

Various physiological investigations in animals have revealed that ascending autonomic pathways are located in the lateral white columns of the cord; and cordotomy operations in man are followed by a more or less complete loss of sensation in viscera the afferent fibres of which reach the cord below the level of the cord section. The incomplete loss is explainable on several grounds: (a) cordotomy operations are usually limited to one quadrant and do not interrupt all the fibres in the lateral white columns; (b) the visceral afferent pathways contain both crossed and uncrossed fibres; and (c) certain visceral afferents may not lie either in the lateral or anterior white columns; for example, it has been suggested that some of the fibres concerned with pressor responses and the state of visceral distension are conveyed in the small postero-lateral fasciculi lying between the tips of the posterior grey columns and the surface of the cord.

The site of entry of afferent pain fibres from several viscera has been determined in man with reasonable accuracy by clinical studies of patients with referred pain of visceral origin, or of those subjected to rhizotomies, surgical or chemical sympathectomies, or spinal anaesthesia. The information available is summarized in tabular form (pages 44 and 45) for ease of reference, but it must be accepted with some reservation, since section of the dorsal nerve roots supposed to transmit certain visceral pain afferents does not always abolish all painful impulses from the viscus concerned. This has led to a search for alternative pathways and there is unconfirmed evidence that some visceral afferents enter the cord through the ventral nerve roots, while the multiple interconnexions in autonomic plexuses and between autonomic nerves favour the occurrence of individual variations. Moreover, since many autonomic pain fibres accompany vessels, any vascular anomalies may be associated with rearrangements in the normal nerve pattern.

Visceral pain afferents usually run with sympathetic fibres, although this is not invariable; for example, the pain fibres from the rectum, the cervix uteri, the prostate and the related parts of the bladder and urethra form parts of the parasympathetic pelvic splanchnic nerves and enter the cord through the sacral dorsal nerve roots. This explains why low spinal or caudal anaesthesia abolishes the perception of painful stimuli from these regions.

It is possible that the visceral pain afferents are not always separate entities, but are the same fibres which normally transmit information about the state of tension in the visceral or vascular musculature or from the various chemoreceptor areas. Sensations of pain or discomfort may be produced by excessive or abnormal stimulation of the nerve endings associated with these fibres. That this is not invariably true is proved by ... ain are abolished by interruption of fibres ... et it is known that many other important cardiac afferents travel in the vagi (see page 76).

The evidence therefore suggests that the central parts of the visceral afferent axons, entering the brain or cord through certain cranial nerves and dorsal spinal nerve roots, form synapses near their sites of entry with cells in the nuclei of these cranial nerves or in the lateral or posterior grey columns of the cord, although all the fibres may not relay at their level of entry into the central nervous system. The same fibres, or a fresh relay resulting from the synapses, decussate almost immediately, and form ascending pathways lying in or near the opposite lateral and anterior spinothalamic tracts and spinal lemniscus, through which they are conveyed to the hypothalamus, thalami and cortex; the fibres may relay or terminate in the hypothalamus, which thus occupies a similar position in autonomic afferent pathways as does the thalamus in the somatic pathways. The fibres relaying in the hypothalamus pass directly, or more often *via* another relay in the medial (dorso-medial) thalamic nuclei, to the frontal and orbital gyri and interruption of these fibres by bilateral leucotomy operations is being used increasingly for the relief of intractable visceral pain. A proportion of the fibres may remain uncrossed and ascend in or near the homolateral spinothalamic tracts, and others may lie in the postero-lateral fasciculi. An unknown percentage never reach the higher levels, but end by forming synapses with efferent cells in the cord, brain-stem or hypothalamus, so completing autonomic reflex arcs

Inclusion of other pathways in autonomic nervous system

Strictly speaking, the autonomic receptors in viscera and vessels are proprioceptive in type, and the question arises whether or not some at least of the other proprioceptive fibres should be regarded as autonomic rather than somatic, for example, the proprioceptive fibres concerned with the tonus, plasticity and irritability of voluntary muscles. Hitherto the afferent and efferent pathways concerned have always been classed as somatic. Yet the effects produced are quite as much outside voluntary or volitional control as are visceral functions and, although the evidence is profuse and unusually contradictory, the more impressive reports favour the view that sympathetic fibres, which undoubtedly end in close relationship to striated muscle cells, play some part in the non-volitional activities of striated muscles. There are grounds, therefore, for including both the afferent and efferent pathways concerned in the autonomic nervous system, and it is, perhaps, significant that the cortical areas subserving voluntary and involuntary activities of the striated muscles ...

or on cortical centres and their association fibres.

SYMPATHETIC

Structure	*Location of nerve cells*			*Efferent pathways Text pages with relevant information*	*Functions*
	Afferent or receptor	*Intercalary or pre-ganglionic*	*Efferent or post-ganglionic*		
Orbital structures	*The afferent nerve cells are found in dorsal spinal root ganglia and the central processes enter the cord through the corresponding nerve roots (see pages 42–43). In general their numbers coincide more or less closely with the numbers of the segments in which the intercalary nerve cells are located, because the majority of the fibres reputedly relay soon after entering the cord. The figures given for these locations are based mainly on Head's work (1893), with additions and modifications necessitated by the observations of subsequent workers. The figures given are approximate only and individual variations upwards or downwards may occur*	Th. 1 and (2)	Superior cervical ganglion	64	Dilatation of pupil (effected in some circumstances by relaxation of sphincter rather than by active dilatation): widening of palpebral fissure: vasoconstriction
Vessels of brain and meninges		Th. 1 and 2	Superior cervical or internal carotid ganglia	67	Vasoconstriction
Salivary glands		Th. 1 and 2	Superior cervical ganglion	67	Vasoconstriction and ? secretion
Heart		Th. 1–4 or 5	All cervical and upper 4 or 5 thoracic ganglia. ? Cardiac plexus	75–77	Tachycardia and vasodilatation of coronary arteries. Pain afferents carried in upper thoracic dorsal nerve roots
Pulmonary structures		Th. 2–6 or 7	(Middle) and inferior cervical and upper 5 or 6 thoracic ganglia	77	Bronchial dilatation. Vasoconstriction and ? some vasodilatation. Transmit afferents from visceral pleura
Oesophagus		Th. 4–6	? Inferior cervical and upper 6 or 7 *thoracic ganglia*	49, 53 and 72	Diminution of peristalsis. ? contraction at cardiac orifice. Conduction of pain
Stomach		Th. 6–9 or 10	Coeliac plexus and ? thoracic ganglia	82–83	Diminution of peristalsis and secretion: contraction of pylorus, vasoconstriction. Conduction of pain
Gall-bladder and bile ducts		Th. 4–10	Coeliac plexus	82	Diminution of peristalsis: transmit pain afferents
Liver		Th. 6–9	*Coeliac plexus*	82	*Vasoconstriction*
Pancreas		Th. 6–10	Coeliac plexus	82	? Vasoconstriction, slight secretion and conduction of pain
Small intestines		Th. 9–11	Coeliac and superior mesenteric ganglia	83	Diminution of peristalsis and secretion. Pain conduction. ? Vasoconstriction
Caecum and appendix		Th. 10–12	Coeliac and superior mesenteric ganglia	83	Diminution of peristalsis and secretion: conduction of pain
Colon to splenic flexure		Th. 12–L. 1	Superior and inferior mesenteric ganglia	83	As above
Splenic flexure to rectum		L. 1–2	Inferior mesenteric and superior and inferior hypogastric *plexuses*	83	Diminution of peristalsis and secretion: contraction of involuntary sphincter. ? Vasoconstriction
Suprarenal medulla		Th. 11–L. 1	Cells of medulla	84	Secretion
Kidney		Th. 11–L. 1 (2)	Coeliac plexus and *renal ganglia*	84	Vasomotor effects: ? effect on secretion. Pain *conduction*
Ureter		L. 1–2	Renal, superior and inferior *hypogastric* plexuses, and ? sympathetic trunks	88	? Diminution of peristalsis. ? Conduc*tion of pain*
Bladder		Th. 12–L. 1	Superior and inferior hypogastric plexuses and ? sympathetic trunks	88	? Diminution of peristalsis: contraction of internal sphincter during ejaculation: vasoconstriction. ? Conduction of pain afferents from fundus
Uterus		Th. 11–L. 1	Inferior hypogastric plexus and ? sympathetic trunks	89	Contraction of pregnant uterus: normally inhibitory to non-pregnant uterus. Transmit pain afferents from fundus
Extremities		There is some divergence of opinion about the exact number of spinal segments containing intercalary neurones for the limbs and the exact limits of their outflows in white rami. [illegible]			

PARASYMPATHETIC

Afferent or receptor	Location of nerve cells: Intercalary or pre-ganglionic	Location of nerve cells: Efferent or post-ganglionic	Efferent pathways Text pages with relevant information	Functions
The afferent cells for the cranial parasympathetic nerves lie mainly in the ganglia on the roots of various cranial nerves (fifth, seventh, ninth and tenth) which are the homologues of dorsal spinal root ganglia, their central processes enter the brain-stem through the various nerves and end in the manner indicated in the text under the various nerves (see pages 42 and 46–48) The afferent pain fibres from the cervix uteri, prostate, bladder (possibly only basal parts), urethra and rectum are carried in the pelvic splanchnic nerves (pages 43 and 58–60), and their cells are located in the dorsal root ganglia of the corresponding sacral nerves	? Edinger-Westphal and caudal central components of third nerve nucleus	Ciliary ganglion	—	Contraction of sphincter pupillae (constriction of pupil) and ciliaris muscle (accommodation) ? Vasodilator. Carry afferents from choroid, iris and cornea
	? Nucleus of seventh nerve	? Facial ganglion or ganglia along vessels	47 and 67	? Vasodilatation of cerebral and meningeal arteries
	(1) For submandibular and sublingual in superior salivary nucleus (2) For parotid in inferior salivary nucleus	(1) Submandibular ganglion (2) Otic ganglion	47–48	Secretion of saliva and vasodilatation
	Dorsal vagal nucleus	Intrinsic cardiac ganglia ? cardiac plexus	48 and 75–77	Bradycardia constriction of coronary arteries transmission of afferents of various kinds but not pain fibres
	Dorsal vagal nucleus	Anterior and posterior pulmonary plexuses	49 and 77	Bronchoconstriction ? secretion ? vasodilatation Transmit afferent fibres from main bronchi
	Dorsal vagal nucleus	Myenteric and submucous plexuses	49 and 53	Increases peristalsis ? secretion ? relaxation of thickening of circular muscle coat at lower end (cardiac sphincter) conduction of afferents
	Dorsal vagal nucleus	*Myenteric and submucous plexuses*	*53 and 58*	Increases peristalsis and relaxes pyloric sphincter Increases secretion ? Conduction of sensations connected with nausea and hunger
	Dorsal vagal nucleus	Terminal ganglia in or near structures	53	Increase of peristalsis and relaxation of sphincter of Oddi
	Dorsal vagal nucleus	Terminal ganglia	53	? Increases secretion ? vasodilatation
	Dorsal vagal nucleus	Terminal ganglia	58	Increases secretion ? vasodilatation
	Dorsal vagal nucleus	Myenteric and submucous plexuses	58	Increases peristalsis and secretion ? conduction of certain afferents
	Dorsal vagal nucleus	*Myenteric and submucous plexuses*	58	*As above*
	Dorsal vagal nucleus	Myenteric and submucous plexuses	58	As above
	Cells in lateral parts of ventral grey columns in mid-sacral segments	Myenteric and submucous plexuses	59	Increase of peristalsis and secretion, relaxation of involuntary rectal sphincter conduction of pain and ? other afferents
	? Dorsal vagal nucleus	?	—	Existence of parasympathetic innervation not proved
	Dorsal vagal nucleus	Small ganglia close to kidney	58	? Vasodilatation and other unknown functions
	? Cells in lateral parts of ventral grey columns in mid-sacral segments	Small ganglia on ureteric nerves ? inferior hypogastric plexus	60 and 89	? Increases peristalsis ? conduction of pain
	Cells in lateral parts of ventral grey columns in mid-sacral segments	Vesical plexus	58 59	Increases peristalsis (detrusor effect) and relaxes internal sphincter *conduction* of pain afferents from base and ? other parts
	Cells in lateral parts of ventral grey columns in mid-sacral segments	Inferior hypogastric plexus and particularly its paracervical ganglia	58 59	Vasodilatation Effect on musculature equivocal Entire genital tract evinces high degree of automatic (spontaneous) activity and hormonal control may be more important than nervous

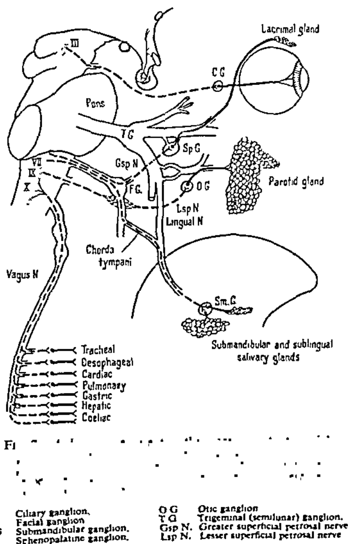
There is no known parasympathetic innervation of structures in the extremities. The suggestion that vasodilator

THE PARASYMPATHETIC COMPONENT

The parasympathetic fibres form integral parts of various cranial and sacral nerves. All are not of equal clinical importance and attention will be confined to those of most surgical interest. Topographical details readily available in anatomical text-books are not given.

The trigeminal, facial and glossopharyngeal nerves

The autonomic components in these nerves flit from one to another in a complex manner and they are best considered together. The fifth nerve performs a largely passive role, merely acting as a vehicle for autonomic fibres that do not arise in its



Fi

own nuclei of origin, but join its various branches through interconnexions with the facial and glossopharyngeal nerves and with the sympathetic plexuses accompanying the carotid arteries. Nevertheless, certain visceral and vascular afferents from the eyes and from branches of the external carotid artery do enter the brain through the sensory root of the trigeminal nerve.

The facial nerve supplies secretomotor fibres to the lacrimal, submandibular and sublingual glands (Fig. 7), and conveys taste fibres from the anterior two-thirds of the

tongue and from the soft palate. It may also carry vasodilator fibres to these glands and to certain cerebral, meningeal and other arteries. The salivary secretomotor fibres of the facial nerve originate in the superior salivary nucleus in the lower pons and they emerge from the brain in the main part of the seventh nerve. They pass into the chorda tympani branch of the facial nerve, which ultimately joins the lingual branch of the mandibular division of the trigeminal nerve. They leave the lingual nerve as the motor root of the submandibular ganglion in which they relay. The efferent or post- ... directly to the submandibular gland and some rejoin the lingual

... cerned with taste and their cells lie in the facial ganglion. Most of the peripheral processes of these cells reach the anterior two-thirds of the tongue *via* the chorda tympani and lingual nerves, but a few follow a more devious route through the greater superficial petrosal nerve, the nerve (Vidian) of the pterygoid canal, communications between the latter and the otic ganglion, and then through interconnexions between the

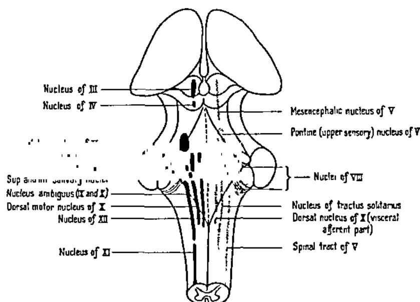


FIG. 8—Diagram illustrating the positions of the cranial nerve nuclei in the brain stem. The sensory nuclei are shown on the right side (stippled) and the motor nuclei on the left side.

ganglion and the chorda tympani; those to the palate pass through the greater superficial petrosal and Vidian nerves to the sphenopalatine ganglion and are then distributed in its palatine branches. The central processes of the facial ganglion cells enter the brain-stem and become associated with taste fibres from the ninth and tenth nerves to form the tractus solitarius, and the fibres end in cells commingled with the tract—the nucleus of the solitary tract (Fig. 8); anatomically and functionally this nucleus is related to the salivary nuclei.

The glossopharyngeal nerve contains secretomotor and possibly vasodilator fibres for the parotid gland (Fig. 7) and the taste afferents for the posterior third of the tongue. It also contains afferent fibres from the carotid body and sinus which end centrally, by forming synapses along with corresponding fibres carried in the vagus, in vasomotor reflex centres in the medulla; certain forms of recurrent syncope and convulsive seizures have been cured by surgical resection of these sinus nerves.

The parotid fibres arise in the inferior salivary nucleus which lies in the reticular formation of the medulla below the superior salivary nucleus, and they emerge from the brain-stem in the glossopharyngeal nerve. Both salivary nuclei are situated in the rostral prolongation of the dorsal vagal nucleus and are of the visceral efferent type (Fig. 8). The fibres leave the ninth nerve in its tympanic branch and are continued in the lesser superficial petrosal nerve to the otic ganglion, where they relay. The efferent or post-ganglionic fibres are conveyed through filaments from this ganglion to the auriculo-temporal branch of the mandibular division of the trigeminal nerve and then through its parotid branches to the gland (Fig. 7). These parotid branches of the auriculo-temporal nerve have sometimes been divided as part of the treatment of salivary fistulae; and they are involved also in gustatory sweating (the auriculo-temporal syndrome) which is an occasional sequel of cervical sympathectomy.

The taste fibres for the posterior third of the tongue are the peripheral processes of cells located in the inferior (petrous) ganglion of the glossopharyngeal nerve. Their central processes enter the medulla and help to form the tractus solitarius mentioned above.

The vagus nerve

The tenth or vagus nerve, as its name implies, wanders far afield to supply multiple structures in the head, neck, thorax and abdomen. It contains much the largest outflow of cranial parasympathetic fibres and is conjoined in the region of the jugular foramen with the cranial root of the accessory (spinal accessory) nerve; the latter contains fibres which are distributed mainly in the pharyngeal and laryngeal branches of the vagus and perhaps also in its cardiac branches.

Nuclei of origin

The vagus has three nuclei of origin in the medulla (Fig. 8).

Dorsal vagal nucleus.—The elongated dorsal vagal nucleus, which lies under the floor of the fourth ventricle, represents a fusion of general visceral efferent and afferent columns. Ending within it are afferent fibres from the heart, great vessels, larynx, trachea, bronchi, lungs, and from most of the alimentary tract (pharynx to splenic flexure) and its associated glands (liver, pancreas and others). Intercalary or preganglionic fibres for the innervation of all corresponding involuntary muscle fibres in the structures mentioned, and secretomotor and possibly vasodilator fibres for the associated glands, arise in the same nucleus. Most observers believe that the vagus also helps in the innervation of the kidney.

Nucleus of the tractus solitarius.—Taste fibres travelling through the main nerve and its internal laryngeal branch from the epiglottis and valleculae help to form the tractus solitarius and end in the lower end of the nucleus of the tractus solitarius, which represents the special visceral afferent column.

The nucleus ambiguus.—This supplies fibres to the voluntary muscles in the pharynx and larynx and represents the special visceral (branchial) efferent column.

Cell stations

The cell stations of the visceral sensory fibres lie in the inferior (nodose) ganglion situated on the vagal trunk just below the jugular foramen. The peripheral processes of the unipolar cells pass to the various structures detailed above and the central processes enter the medulla to form synapses in the dorsal vagal nucleus with intercalary neurones. The axons of the latter (pre-ganglionic fibres), in conformity with the general arrangement in the parasympathetic system, form synapses in terminal ganglia situated near or within the viscus to be innervated, so that the efferent or post-ganglionic fibres are short.

Intercommunications

A point of practical importance, and one seldom or never stressed, is the fact that the vagi form frequent intercommunications with sympathetic nerves and ganglia in [illegible]

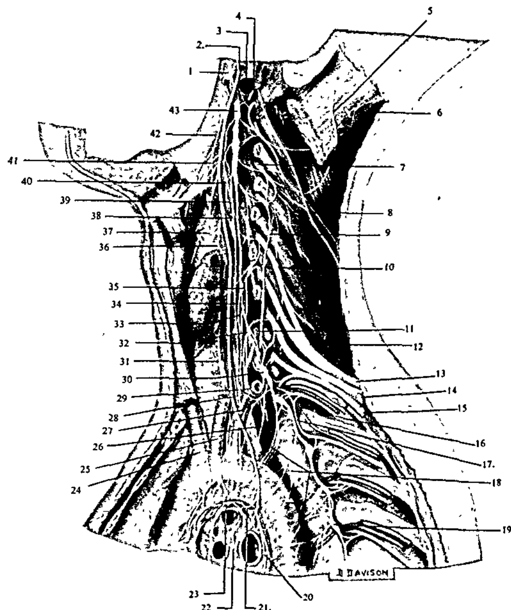
efferent and afferent fibres pass through these interconnexions, and there is good evidence that in some animals (for instance, cats) afferent fibres leave the vagus and oesophageal plexus in the thorax to pass through sympathetic ganglia, rami communicantes and dorsal thoracic spinal nerve roots to the cord. These afferents transmit painful and other visceral sensations, and there are grounds for believing that pain fibres from the abdominal viscera are not carried to the brain through the vagi. It is a mistake to imagine, therefore, that a vagotomy in the region of the diaphragm destroys only parasympathetic efferent abdominal fibres, for at this level the vagi probably contain both afferent and efferent sympathetic and parasympathetic fibres.

Lower thoracic and abdominal portions

Operations upon the vagi are usually confined to their lower thoracic and abdominal portions, so these will be described in more detail. As for the other parts, it will suffice to say that in the neck, branches are supplied to the pharynx, larynx (superior and right recurrent laryngeal nerves), trachea, oesophagus, carotid sinus and heart; and in the thorax to the heart, great vessels, larynx (left recurrent laryngeal nerve), trachea, bronchi, lungs and oesophagus (Figs. 9, 10 and 11). All are important, and some, such as the cardiac and pulmonary branches, will be mentioned again when discussing the corresponding plexuses. Others, such as the laryngeal nerves, are of surgical interest because of their relationship to the thyroid gland, aortic arch, great vessels and other structures, and their possible involvement in diseases or operations on these. The afferents carried from the heart, great vessels and carotid sinus to vasomotor reflex centres in the medulla are vitally important. Theoretically, interruption of the parasympathetic supply to the bronchi should relieve spasm as in asthma, but the vagal and sympathetic fibres are so closely admixed that division of one group without interruption of the other is scarcely feasible: high section of both vagi in the neck is indefensible for obvious reasons.

Below the lung roots both vagi usually divide into 2–4 main branches which lie in close relationship to the lower oesophagus. The right and left branches both pursue an oblique course, so that the former comes to lie on the posterior and the latter on the anterior aspect of the gullet, and they intercommunicate to form an open-meshed plexus gulae surrounding the lower thoracic portion of the oesophagus. Although the right vagal branches form the major portion of the posterior half of this oesophageal plexus, they always contribute some fibres to the anterior half and the left vagus behaves in a similar but reverse fashion. The plexus is joined by sympathetic filaments from the thoracic gangliated trunks and greater (superior thoracic) splanchnic nerves, and gives off numerous filaments which sink into the oesophageal walls and supply also adjacent structures such as the thoracic duct. The relative absence of connective tissue between the constituent parts of the plexus gulae contrasts with the abundant connective tissue found in several other autonomic plexuses such as the coeliac and hypogastric. Thus in most cases the plexus is revealed as soon as the mediastinal pleura is displaced or removed (Fig. 10).

Immediately above the diaphragm, or actually within its oesophageal hiatus, the branches of the plexus re-unite into two or more short vagal trunks which enter the abdomen and lie anterior and posterior to the gastro-oesophageal junction. There is no constant number, but it is unusual to find more than two, and sometimes there is



1 Internal carotid plexus.
2. Vagus nerve
3 Internal jugular nerves.
4 Hypoglossal nerve
5 Great auricular nerve.
6 Lesser occipital nerve
7 Anterior division of third cervical nerve
8 Accessory nerve
9 Phrenic nerve
10 Anterior division of fifth cervical nerve (uppermost root of brachial plexus)
11 Vertebral artery
12. *Upper trunk of brachial plexus.*
13, 14, 15 Lateral, posterior and medial cords of

22. Anterior pulmonary plexus.
23 Cardiac plexus
24 Innominate artery
25 Left common carotid artery
26 Inferior cervical sympathetic cardiac nerve
27 Left subclavian artery
28 Lower cervical cardiac branch of vagus.
29 Ansa subclavia.
30 Inferior cervical sympathetic ganglion.
31 Left recurrent laryngeal nerve
32. Vertebral ganglion (ganglion intermédiaire).
33 Middle cervical sympathetic cardiac nerve
34 *Conjoined superior cardiac branches from vagus and superior cervical ganglion.*

42. Internal laryngeal nerve
43 Superior cervical sympathetic ganglion.

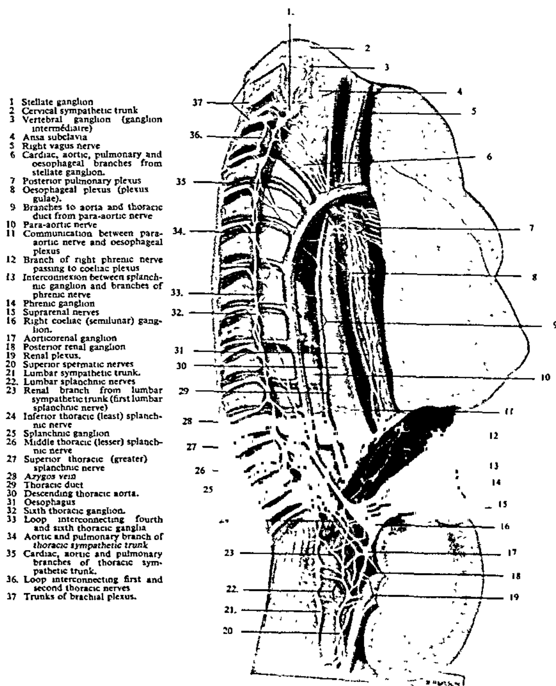


FIG. 10 —A dissection from the lateral side showing the autonomic nerves. To display them the right lung, suprarenal and kidney have been rotated to the left side, part of the diaphragm cut away and the liver removed.

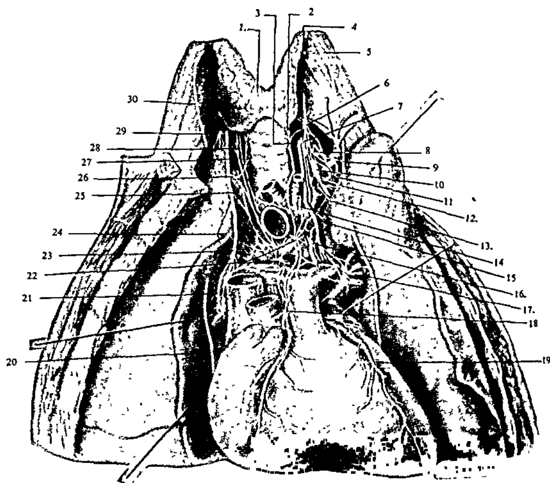


FIG. 11 —Composite drawing of dissection of lower neck and thorax. Parts of both sympathetic trunks and their branches behind the lungs are indicated by dotted outlines

1. Thyroid gland (left lobe partly removed).
2. Left recurrent laryngeal nerve
3. Left vagus nerve
4. Conjoined superior cardiac branches from vagus nerve and superior cervical ganglion
5. [illegible]

[illegible]

sympathetic trunk

16. Left recurrent laryngeal nerve
17. Left anterior pulmonary plexus.

[illegible]

21. [illegible]
22. [illegible]
23. [illegible]
24. [illegible]

[illegible]

28. Right superior cervical cardiac sympathetic nerve
29. Lower end of right middle cervical ganglion.
30. Upper part of phrenic nerve.

only one, on each aspect. Of course, at a somewhat higher level there may be 3–5 or even more branches on each aspect of the oesophagus, and some writers describe these incorrectly as vagal trunks; they are really the lower ends of the oesophageal plexus. As a rule the main trunks lie on the surface and are not buried in the muscular coats of the oesophagus or stomach. Each trunk contains a proportion of fibres from both vagi, although right and left fibres preponderate in the posterior and anterior trunks respectively, and both also contain sympathetic fibres.

The above arrangement is the most common, but variations occur. Thus, in about 2–3 per cent of subjects the relationship of the nerves to the oesophagus is reversed, the right vagus playing the major part in the formation of the anterior oesophageal plexus and vagal trunk, and the left nerve being directed posteriorly; and in about 1 per cent no true oesophageal plexus exists, the two vagi becoming reconstituted into single trunks below the lung roots, whence they pass downwards on the oesophagus, the left being anterior and the right posterior.

Anterior vagal trunk.—The anterior vagal trunk (Figs. 12 and 13) supplies several filaments to the cardiac orifice before dividing near the proximal end of the lesser curvature into four groups of branches. (1) gastric, (2) pyloric, (3) hepatic and (4) coeliac.

(1) There are 4–10 gastric branches and they radiate to supply the anterior surface of the stomach almost as far down as the pylorus Frequently one branch, the greater anterior gastric nerve, is larger than the others and lies along the anterior surface of the lesser curvature between the layers of the lesser omentum, where it communicates with the adjacent sympathetic filaments and with branches of the posterior vagal trunk. A true anterior gastric plexus in the accepted sense of the term is a rarity.

(2) The pyloric branches are usually two in number. One arises near the cardiac orifice and the other about half-way along the lesser curvature, and they run horizontally to the right between the layers of the lesser omentum and then turn downwards on the left side of the hepatic artery to reach the pyloric antrum, pylorus and proximal part of the duodenum. They always intercommunicate with the hepatic plexus, and the branch arising distally actually supplies the proximal part of the area supplied by them, that is, the pyloric antrum and pylorus

(3) There are 2–4 hepatic branches which arise from the anterior vagal trunk and from its greater anterior gastric branch. They pass to the right and either join the plexus around the hepatic artery or enter the porta hepatis directly. It is often possible to trace filaments to the common and cystic ducts and to the gall-bladder.

(4) The coeliac branches are small and run along the left gastric artery to the coeliac plexus, frequently uniting with the coeliac division of the posterior vagal trunk Other fine contributions to the coeliac plexus come from the pyloric and hepatic branches of the anterior trunk and reach the plexus alongside the hepatic artery

The posterior vagal trunk.—This may be single, double or rarely triple Two main sets of branches, gastric and coeliac, are supplied by this trunk and the coeliac division is usually the larger of the two (Figs. 14 and 15).

(1) The gastric branches are distributed in a manner reminiscent of their anterior counterparts, although their area of supply is slightly less extensive. There is a similar greater posterior gastric nerve lying parallel to the lesser curvature, and apart from its gastric branches and communications with the corresponding anterior nerve, it may give off a contribution to the coeliac plexus; in these cases the coeliac division is smaller than the gastric. The posterior branches reach only to the pyloric antrum and, apparently, do not supply the pylorus, and they, too, supply fine hepatic filaments like the corresponding anterior branches As on the anterior aspect, no true posterior gastric plexus exists

(2) The coeliac division is usually larger and at first sight it seems to consist of a single nerve, but dissection shows that it often consists of 3–4 closely apposed branches



Fi [illegible]

1. Right vagus.
2 Oesophagus
3 Left vagus
4 Descending thoracic aorta
5. Anterior vagal trunks
6. Fundus of stomach.
7 Spleen.
8 Branches to cardiac orifice and upper part of lesser curvature.
9 Greater anterior gastric nerve ("principal anterior nerve of lesser curvature")
10 Transverse colon
11. Right gastro-epiploic nerves (derived from hepatic plexus through gastro-duodenal plexus)
12. Pylorus
13 Pyloric branches
14 Branches to liver and gall-bladder
15 Cut surface of liver
16. Hepatogastric nerve connecting hepatic plexus with gastric nerves along lesser curvature
17. Branch passing to coeliac plexus.



FIG 13—The anterior vagal trunk and its branches and part of the hepatic plexus. The liver has been rotated in an anti-clockwise direction so that the left lobe lies above the right. Thin black paper has been placed behind the nerves for photographic purposes.

1 Anterior vagal trunk
2. Branches to cardiac orifice and fundus
3 Greater anterior gastric nerve ("principal anterior nerve of lesser curvature")
4 Filament accompanying left gastric artery (artery removed)
5 Pyloric branch
6 Hepatic plexus.
7 Mixture of hepatic filaments from vagal trunk and hepatogastric filaments passing from hepatic plexus to stomach
8 Gastric and hepatic branch from right phrenic plexus.

L. Liver
P Pylorus.
S Body of stomach.



Fig. 14. A dissection showing the posterior vagal trunk and certain of the gastric, pancreatic, [illegible]

1. Posterior part of oesophageal plexus (plexus gulae)
2. Descending thoracic aorta
3 Spleen
4 Posterior vagal trunk
5 Coeliac division of posterior vagal trunk
6 Splenic nerves
7 Pancreas
8 Pancreatic and splenic nerves.
9 Left coeliac (semilunar) ganglion.
10 Transverse colon
11 Nerves passing to descending colon.
12. Cut surface of liver
13 Duodenum.
14 Termination of gastro-duodenal nerves and commencement of right gastro-epiploic branches
15 Pylorus
16 Hepatic plexus at point where it gives off right gastric plexus (passing to left above pylorus) and gastro-duodenal plexus (passing downwards between duodenum and head of pancreas)
17. Branches to pyloric region from vagus and left gastric sympathetic plexus.
18 Left gastric plexus
19 Greater posterior gastric nerve ("principal posterior nerve of lesser curvature")
20 Cut edge of diaphragm

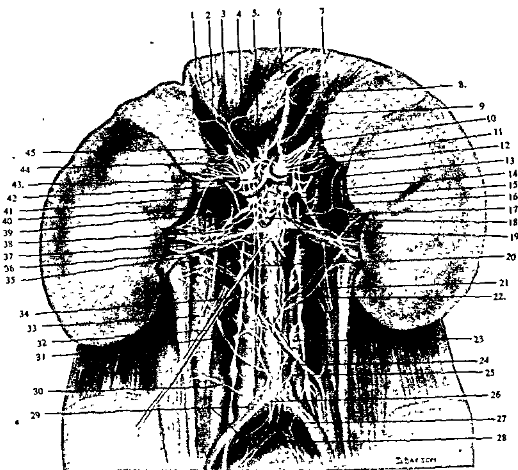


FIG 15 —Visceral nerves in abdomen. The lumbar sympathetic trunks are easily distinguishable and are not numbered.

1 Branch of right phrenic nerve to phrenic plexus

20 Intermesenteric nerves.
21 Second lumbar splanchnic nerve
22. Renal branches from lower ends of intermesenteric nerves.
23 Third lumbar splanchnic nerve
24 Inferior mesenteric plexus
25 Interconnexion between superior hypogastric and inferior hypogastric plexuses
26 Superior hypogastric plexus (pre-sacral nerve)
27 Fourth lumbar splanchnic nerve.
28 Hypogastric nerves (plexuses)
29 Iliac branches from superior hypogastric plexus and right hypogastric nerve
30 Middle ureteric and spermatic nerve
31 Renal and ureteric branch from superior hypogastric plexus.
32. Superior spermatic nerves
33 Interconnexion between renal plexus and superior spermatic nerve
34 Lumbar splanchnic nerves
35 Small renal ganglion.
36 Renal branch from lumbar sympathetic trunk.

united by interconnexions in a plexiform manner. All branches end in the coeliac plexus, being approximately divided equally between its two halves. Owing to the multiple intricate interconnexions in the coeliac plexus it is impossible to trace the ultimate distribution of individual branches, but owing to the relatively large size of the coeliac contributions from the posterior vagal trunk they must contain most of the parasympathetic vagal fibres for the abdominal viscera, except the stomach and the liver, besides an unknown proportion of sympathetic fibres derived from the interconnexions between the vagi and the sympathetic trunks or their branches.

Function

The majority of the abdominal viscera are innervated by the vagi—the stomach, the small intestines, the large gut almost to the splenic flexure, the liver, pancreas, spleen and kidneys. The vagi produce contraction or peristalsis of all unstriated muscle in the walls of the various hollow viscera they supply, but relaxation of any sphincter mechanisms. They are secretomotor to glands, and they also carry vasodilator fibres. Thus vagotomy reduces visceral motility and glandular secretion. For example, in the stomach it diminishes peristalsis and acid secretion, so providing conditions favourable for the healing of peptic ulcers; but it also reduces hepatic and pancreatic secretion, probably including the output of insulin, and these effects, plus the interruption of afferent and sympathetic fibres in the vagal trunks, may well explain some of the undesirable sequelae of the operation. Incidentally the effect of deliberate vagotomy in attempting to control an excessive secretion of insulin has apparently not yet been tried, and it might be justifiable in such cases to try division of the posterior vagal trunk(s) or of its coeliac division. The function of the renal vagal innervation is unknown.

The myenteric and submucous plexuses

The intrinsic nerves of the alimentary tract, with the exception of the pharynx where the plexus is located on the surface, form plexuses containing numerous and closely interconnected groups of ganglion cells which lie between the layers of the muscular coats (myenteric or Auerbach's) and in the submucosa (submucous or Meissner's). [illegible] plexus and its nerve bundles are finer. Both [illegible] synapses with the intercalary or pre-ganglionic fibres of the vagi or pelvic splanchnic nerves, depending on the areas of supply in which they lie. *The sympathetic fibres pass* through the plexuses without synaptic interruptions to their terminations. Many believe that these plexuses include intrinsic reflex mechanisms through which certain automatic enteric activities are mediated.

Pelvic splanchnic nerves or nervi erigentes

These nerves (Figs. 16 and [illegible] from the *caudal end of the neuraxis.* [illegible] the pelvic viscera and genitalia, to the distal colon, and perhaps also to the [illegible] pelvis and ureter. Their detrusor effects on the bladder and distal colon are usually unquestioned, but doubts have been expressed about their effects on the uterus. At present the popular view *is that any uterine parasympathetic effect is vasodilator.* This idea is based on physiological experiments, and as assumptions based on similar [illegible] view [illegible] has [illegible] *luced* it would be precipitate to abandon the view that normal visceral activities are the result of balanced sympathetic and parasympathetic reactions.

The nervi erigentes also transmit afferents from the same viscera. It is known that pain fibres from the cervix uteri, prostate, bladder, urethra and rectum reach the cord through these nerves. On the other hand, those from the body of the uterus run through the superior hypogastric plexus (pre-sacral nerve). These anatomical facts explain why pre-sacral neurectomy relieves certain types of dysmenorrhoea, but not pain resulting from lesions affecting the cervix uteri or prostate; in malignant diseases of the latter, pain usually indicates spread into the paracervical or paravesical tissues with involvement of both somatic and autonomic branches of the sacral plexus, so that cordotomy alone gives relief. Evidence obtained following low spinal anaesthesia and pre-sacral neurectomy suggests that the pain afferents from the ovaries and uterine tubes are not transmitted either through the nervi erigentes or the superior hypogastric plexus, but through the ovarian plexus.

The nervi erigentes arise from the anterior primary rami of the second, third and fourth, and occasionally also from the fifth, sacral nerves. The largest outflow of fibres is usually through the third nerve, with smaller contributions from the second or from the fourth or from both, and any filaments from the fifth are relatively insignificant. The fibres may be aggregated into 2–3 branches, but more often there are multiple filaments which pass to, and become incorporated in, the inferior hypogastric or pelvic plexus. Some fibres may relay in the plexus and others in minute ganglia situated near or in the walls of the individual viscera. Occasionally it is possible to trace direct filaments from the pelvic splanchnic nerves to the rectum, bladder and cervix uteri.

The parasympathetic supply to the distal colon, corresponding to the part developed from the hind gut, usually runs in fine, long nerves (Fig. 17) which arise by several rootlets from the inferior hypogastric plexus and hypogastric nerves, or rarely as direct offshoots from the nervi erigentes, and pass upwards across the sigmoid vessels and their accompanying branches from the inferior mesenteric plexus. They generally divide about the lower end of the descending colon and these subdivisions continue upwards to the left colic or splenic flexure. Occasionally they continue as single nerves almost to their terminations, or infrequently the right and left nerves unite to form a single trunk which can be traced as far as the end of the transverse colon. They give off fine twigs to the colon throughout their course and communicate with branches of the inferior mesenteric plexus This arrangement explains why an operation such as that of Rankin and Learmonth, in which the inferior mesenteric plexus is resected near its origin, may succeed in redressing the sympathetic-parasympathetic imbalance in megacolon, for in most patients this would not interrupt the parasympathetic fibres to the distal colon In a minority, however, they will be endangered, because sometimes the parasympathetic fibres follow an alternative route, being conveyed through the hypogastric nerves into the superior hypogastric plexus, and from the latter through one or more short communicating branches to the commencement of the inferior mesenteric plexus. In such cases ablation of this part of the inferior mesenteric plexus destroys both sympathetic and parasympathetic pathways, and to circumvent such anatomical anomalies lumbar sympathectomy is the preferable operation.

Recently it has been claimed, however, that the autonomic imbalance in patients with Hirschsprung's disease is due to aplasia of the parasympathetic ganglion cells in the myenteric plexus in a segment of the colon. In consequence this segment becomes narrowed due to unopposed sympathetic activity. Sympathectomy will abolish this sympathetic activity, but cannot restore co-ordinated propulsive movements in the affected segment of the gut because of the aplasia in its parasympathetic ganglion cells. Therefore, Bodian, Stephens and Ward (1949) suggest that rectosigmoidectomy is a more scientific and better treatment for the disease.

The evidence that the renal pelvis and ureter, and possibly also the renal collecting

tubules, receive parasympathetic fibres from the sacral rather than the cranial outflow is based, as in the case of the distal colon and rectum, on embryological and anatomical grounds. The collecting tubules, pelvis and ureter are all derivatives of a diverticulum from the mesonephric duct near its entrance into the primitive cloaca, and it is not unreasonable to suppose that structures derived from the hind-gut and from the cloacal extremities of the mesonephric ducts are innervated from the sacral rather than the cranial parasympathetic outflow.

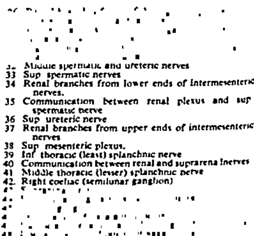
Anatomically it can be shown in the majority of subjects (19 out of 23 dissections) that the renal pelvis and ureter receive a nerve supply from the superior hypogastric plexus or from the lower ends of the intermesenteric nerves or from both (Figs. 15, 16 and 17), in addition to the ureteric nerves arising from the inferior hypogastric plexus (page 88). These renal branches pass obliquely upwards and outwards behind the testicular or ovarian vessels and join the infero-lateral part of the renal plexus. Filaments from them can be traced both to the pelvis and ureter. A variant of this arrangement is sometimes seen where these renal nerves on the right side originate from a loop uniting the intermesenteric nerves and the inferior mesenteric plexus. Generally a small ganglion (or ganglia) is present somewhere along their course (Figs. 15, 16 and 17). The hypothetical course of the fibres from the pelvic splanchnic nerves, through the inferior hypogastric plexus, hypogastric nerves and superior hypogastric plexus to the renal nerves described can easily be followed by reference to Fig. 17. When these renal nerves arise more distally, that is, from the superior hypogastric plexus rather than from the caudal ends of the intermesenteric nerves, the kidney on the corresponding side usually possesses more than one artery, and the extra vessel or vessels enter the lowest part of the renal sinus or below it. There is apparently a tendency for cranial or caudal shifts of visceral nerves, for example, to the kidney, testis and ovary, to be associated with corresponding variations in vascular distribution (just as pre-fixation or post-fixation of spinal nerves may be associated with variations in the ribs and vertebrae), an anomaly of practical importance in renal denervation operations.

THE SYMPATHETIC COMPONENT

This is the larger subdivision of the autonomic nervous system. The peripheral parts consist of rami interconnecting the spinal cord and nerves to two paravertebral ganglionated trunks; various pre-vertebral, visceral and vascular plexuses; and

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1 Anterior vagal trunks
2 Posterior vagal trunk.
3 Left phrenic nerve
4 Suprarenal branch of left phrenic nerve
5 Sup thoracic (greater) splanchnic nerve
6 Left coeliac (semilunar) ganglion
7. Middle thoracic (lesser) splanchnic nerve.
8 Left aorticorenal ganglion.
9 Inferior thoracic (least) splanchnic nerve.
10 Post-renal ganglion
11. Renal branch from lumbar sympathetic trunk (first lumbar splanchnic nerve)
12. Intermesenteric nerves
13 Second lumbar splanchnic nerve
14 Lumbar sympathetic trunk.
15 Third lumbar splanchnic nerve.
16 Inferior mesenteric plexus.
17 Renal branch from sup. hypogastric plexus.
18. Sup hypogastric plexus (pre-sacral nerve)
19 Fourth lumbar splanchnic nerve
20 Branch supplying common iliac vessels and joining hypogastric nerve.
21 Left hypogastric nerve (plexus)
22 Rectal and colic branch from hypogastric nerve
23 Pelvic splanchnic nerves (nervi erigentes)
24 Inferior hypogastric (pelvic) plexus.
25 Nerve loops round lower end of ureter giving off inf ureteric nerves.


32 Middle spermatic and ureteric nerves
33 Sup spermatic nerves
34 Renal branches from lower ends of intermesenteric nerves.
35 Communication between renal plexus and sup spermatic nerve
36 Sup ureteric nerve
37 Renal branches from upper ends of intermesenteric nerves
38 Sup mesenteric plexus.
39 Inf thoracic (least) splanchnic nerve
40 Communication between renal and suprarenal nerves
41 Middle thoracic (lesser) splanchnic nerve
42. Right coeliac (semilunar ganglion)

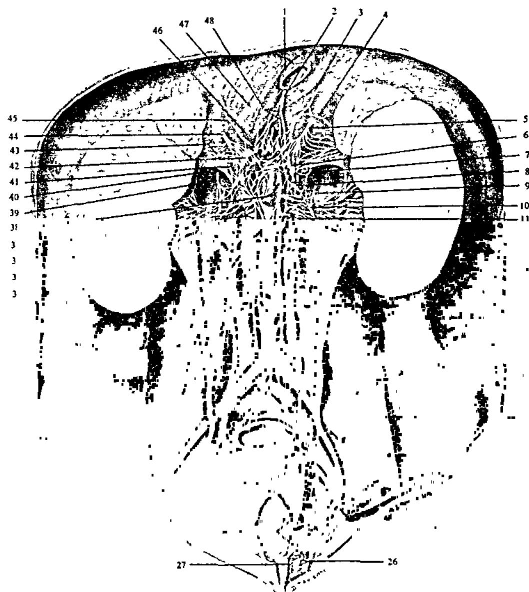
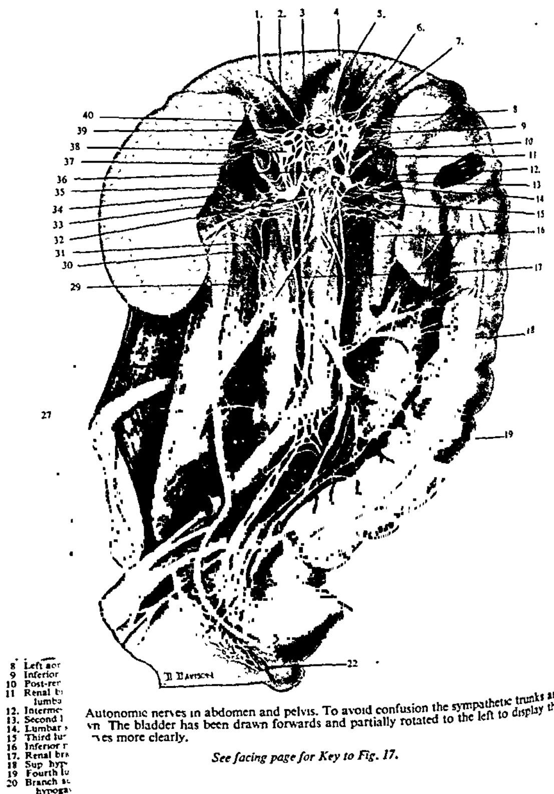


Fig 16—The major abdominal and pelvic autonomic plexuses and their branches. The liver, spleen, pancreas and intestines are not shown and only the lower end of the oesophagus, part of the rectum and the right halves of the bladder and prostate The rectum has been drawn over towards the right. To avoid over-complication the sympathetic trunk is omitted on the right side.

See facing page for Key to Fig. 16.



8 Left aor
9 Inferior
10 Post-rer
11 Renal b
lumba
12. Interme
13. Second l
14. Lumbar
15 Third lu
16 Inferior r
17. Renal bra
18 Sup hyp
19 Fourth lu
20 Branch a
hypoga

Autonomic nerves in abdomen and pelvis. To avoid confusion the sympathetic trunks ar
vn The bladder has been drawn forwards and partially rotated to the left to display th
es more clearly.

See facing page for Key to Fig. 17.

sympathetic fibres which are inherent constituents of most cerebrospinal nerves. The basic arrangement, the limitation of the outflow to the thoraco-lumbar region and other relevant matters are discussed in Volume 1 of *British Surgical Practice*, and this information is not repeated, but additional details are given about the actual nerves and plexuses.

Rami communicantes

The rami communicantes interconnecting the spinal nerves and sympathetic trunks are of three main types—white, grey and mixed.

The white rami.—These consist of medullated fibres, mainly of small size, although some may measure up to 15–20μ in diameter, and they have an off-white, opaque appearance. They are found only in the thoracic and upper lumbar regions and carry the intercalary or pre-ganglionic fibres of the sympathetic outflow. Each ganglion in these regions receives one or more white rami from the corresponding spinal nerves, and sometimes also from the nerve immediately above or below. Occasionally small ganglia are present upon them (*see* page 65).

Grey rami.—The grey rami are composed of small unmyelinated or finely medullated fibres and they are greyish-red in colour. They transmit efferent or post-ganglionic fibres from the sympathetic ganglia to adjacent spinal or cranial nerves, and every ganglion gives off one or more of these rami

Mixed rami.—The mixed rami are confined to the thoraco-lumbar region corresponding to the sympathetic outflow and contain both myelinated and unmyelinated fibres. They represent a fusion of white and grey rami.

Disparities between white and grey rami

The disparity between the number and disposition of the white and grey rami is puzzling unless one remembers that.

(a) Each intercalary or pre-ganglionic axon in the white rami may form synapses with 2–20 or more efferent or post-ganglionic neurones and the axons of many of the latter constitute the grey rami.

(b) The axons in any white ramus do not all relay in the corresponding ganglion of the sympathetic trunk. A proportion pass upwards or downwards in the sympathetic trunk before relaying in higher or lower ganglia, and others run through medially directed branches of the trunks to relay in one or other of the visceral sympathetic plexuses.

Three typical examples may clarify these points.

(1) Pre-ganglionic fibres for the abdominal dermatomes leave the cord through the

1. Branch from right phrenic nerve to phrenic and coeliac plexuses



11. Middle thoracic (lesser) splanchnic nerve.
12. Aorticorenal ganglion.
13. Inferior thoracic (least) splanchnic nerve
14. Posterior renal ganglion
15. Renal plexus
16. Superior ureteric nerve
17. Intermesenteric nerves
18. Inferior mesenteric plexus
19. Nerves to distal colon from inferior hypogastric plexus.
20. Inferior hypogastric (pelvic) plexus.
21. Branches to bladder and lower end of ureter.
22. Branches to prostate
23. Pelvic splanchnic nerves (nervi erigentes)
24. Ureter



30. Renal branches from lower ends of intermesenteric nerves
31. Superior ureteric nerve
32. Anterior renal ganglion.
33. Posterior renal ganglion.
34. Interconnexion between renal and suprarenal nerves
35. Inferior thoracic (least) splanchnic nerve.
36. Superior mesenteric artery—cut end
37. Middle thoracic (lesser) splanchnic nerve.
38. Right coeliac (semilunar) ganglion.
39. Coeliac artery (axis)—cut end
40. Superior thoracic (greater) splanchnic nerve

the sympathetic trunk, the pre-vertebral plexuses and the subsidiary visceral and vascular plexuses, but this would involve considerable repetition. To avoid this, the arrangement will be discussed on a regional basis.

THE SYMPATHETIC SYSTEM IN THE HEAD AND NECK

The cervical part of each sympathetic trunk (Fig. 9) lies posterior to the carotid sheath and anterior to the cervical transverse processes. It includes three main ganglia, superior, middle and inferior, connected by intervening cords, usually single between the superior and middle ganglia and multiple between the middle and inferior ganglia. The ganglia receive no white rami communicantes, but give off grey rami communicantes to all the cervical spinal nerves, and also communicating rami, carrying mainly efferent fibres, to several cranial nerves.

Superior cervical ganglion

The superior cervical ganglion is 1–2 inches long and is fusiform in shape or irregularly constricted. It lies opposite the upper two or three cervical vertebrae, behind the internal carotid artery, internal jugular vein and vagus nerve and in front of the longus cervicis muscle, and it is formed by the coalescence of three or occasionally four ganglia. It contains synapses between intercalary and efferent neurones. The intercalary or pre-ganglionic fibres emerge in the uppermost thoracic spinal nerves and travel upwards in the cervical trunk to the superior ganglion where they relay. The efferent or post-ganglionic fibres are then carried through the multiple branches of this ganglion. It supplies communicating, visceral, vascular and other branches.

Communicating branches

The superior cervical ganglion communicates with the ninth, tenth, eleventh and twelfth cranial nerves near their exits from the skull, with the vertebral plexus, and sometimes communicates also with the phrenic nerve. It supplies grey rami communicantes to the upper three and occasionally four cervical spinal nerves, although the last ramus and the communication with the phrenic nerve, when present, are often derived from the trunk connecting the superior and middle ganglia. The efferent fibres in these communications are distributed along with branches of the nerves they join.

Visceral branches

The superior ganglion contributes laryngeal filaments which join the laryngeal branches of the vagus; pharyngeal twigs which unite with corresponding branches from the glossopharyngeal and vagus nerves to form the pharyngeal plexus located on the surface of that structure; a cardiac branch which arises by several rootlets from the ganglion and from the trunk below it (page 75); and fibres which help in the innervation of the salivary, lacrimal, pituitary and thyroid glands and which are carried in the vascular plexuses.

Vascular branches

Important vascular branches originate from the superior ganglion and accompany the carotid arteries and internal jugular vein.

Internal carotid nerve.—The internal carotid nerve appears to be a direct upward continuation of the trunk from the superior ganglion, lying postero-medial to the internal carotid artery and extending into the carotid canal alongside the artery. Often single at its commencement, it soon divides and subdivides to form the internal carotid plexus, which may contain one or more minute ganglia, and which surrounds and supplies the artery to its termination; some or all of the efferent sympathetic fibres to the cerebral vessels relay in these small ganglia and not in the superior cervical ganglion. The plexus formation is most evident around the part of the artery

... in the carotid canal there are only 2 or 3

... ial nerve in its vicinity—the third, fourth, fifth and sixth nerves, with the greater superficial petrosal branch of the seventh, and with the tympanic branch of the ninth nerve by slender caroticotympanic filaments which pass through canaliculi in the petrous temporal bone. *One branch known as the deep petrosal nerve arises from the plexus* near the point where the artery leaves the carotid canal and joins the greater superficial petrosal nerve to form the nerve of the pterygoid canal which ends in the sphenopalatine ganglion. Offshoots which supply various structures in the eye and orbit are described on page 64.

The plexus terminates in secondary plexuses which surround and supply the anterior and middle cerebral and ophthalmic arteries and their branches. Filaments ...

... Willis. Microscopic bundles of fibres are also said to supply the meninges, although those for the dura and arachnoid are more probably carried in the plexuses surrounding the various meningeal arteries.

The common carotid branches.—These, 2–4 in number, arise from the anterior ... contain ... fibres to the carotid ...

... filaments from the middle and inferior cervical ganglia.

External carotid branches.—The external carotid branches, 4–6 in number, arise above or together with the common carotid filaments and ramify to form a particularly rich plexus around the external carotid artery and its branches, with which they are widely distributed to structures, such as the thyroid and salivary glands, the pharynx, the larynx, the tongue and other buccal structures, the masticatory muscles, ...

... runs to the ganglion of the facial nerve. Relatively few nerve fibres supply the veins.

... This is formed by filaments arising from the upper and ...

... inferior ganglion of the ninth and the superior ganglion of the tenth cranial nerves.

Clinical importance of vascular innervation.—Since most headaches of intracranial origin, and some of extracranial origin also, are associated with abnormal constriction or dilatation of vessels, unusual clinical interest attaches to their innervation. In general, sympathetic vascular fibres produce vasoconstriction and parasympathetic fibres vasodilatation. In most vessels the sympathetic innervation is more evident. This has led to the view that many arteries have no parasympathetic supply and that any dilatation of these vessels is a negative result produced by diminution or temporary disappearance of the tonus normally maintained by sympathetic activity, rather than to any positive effect produced by parasympathetic activity. The cerebral and meningeal arteries provide good illustrations of this point. Their sympathetic innervation has never been seriously questioned, but it was only comparatively recently that proof was obtained of a parasympathetic supply in some animals through fibres transmitted in the facial nerve and its greater superficial petrosal branch; it is assumed that similar fibres exist in man.

Some afferent fibres are mixed up with efferent vasomotor fibres in the sympathetic

the sympathetic trunk, the pre-vertebral plexuses and the subsidiary visceral and vascular plexuses, but this would involve considerable repetition. To avoid this, the arrangement will be discussed on a regional basis.

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lying in the cavernous sinus, and sometimes in the carotid canal there are only 2 or 3 larger filaments with almost microscopic interconnexions.

The internal carotid plexus communicates with practically every cranial nerve in its vicinity—the third, fourth, fifth and sixth nerves, with the greater superficial petrosal branch of the seventh, and with the tympanic branch of the ninth nerve by slender caroticotympanic filaments which pass through canaliculi in the petrous temporal bone. One branch known as the deep petrosal nerve arises from the plexus near the point where the artery leaves the carotid canal and joins the greater superficial petrosal nerve to form the nerve of the pterygoid canal which ends in the sphenopalatine ganglion. Offshoots which supply various structures in the eye and orbit are described on page 64.

The plexus terminates in secondary plexuses which surround and supply the anterior and middle cerebral and ophthalmic arteries and their branches. Filaments alongside the anterior communicating artery interconnect the plexuses of the opposite sides. The hypophysis cerebri (pituitary) receives sympathetic fibres along its vessels of supply which come from the internal carotid arteries and the arterial circle of Willis. Microscopic bundles of fibres are also said to supply the meninges, although those for the dura and arachnoid are more probably carried in the plexuses surrounding the various meningeal arteries.

The common carotid branches.—These, 2–4 in number, arise from the anterior aspect of the superior ganglion and the most important transmit fibres to the carotid sinus and body, where they form a plexus with branches from the glosso-pharyngeal and vagus nerves (*see also* page 47). Below they anastomose with other carotid filaments from the middle and inferior cervical ganglia.

External carotid branches.—The external carotid branches, 4–6 in number, arise above or together with the common carotid filaments and ramify to form a particularly rich plexus around the external carotid artery and its branches, with which they are widely distributed to structures, such as the thyroid and salivary glands, the pharynx, the larynx, the tongue and other buccal structures, the masticatory muscles, the temporomandibular joint, the face, the ear, the scalp, the skull and the meninges. The plexus on the facial artery supplies the sympathetic root to the submandibular ganglion; and that on the middle meningeal artery supplies the sympathetic root to the otic ganglion, in addition to an inconstant twig, the external petrosal nerve, which runs to the ganglion of the facial nerve. Relatively few nerve fibres supply the veins.

The internal jugular nerve.—This is formed by filaments arising from the upper end of the ganglion or from the internal carotid nerve. Fibres are supplied to the superior jugular bulb and a few may be distributed to the meninges, but the majority end in the inferior ganglion of the ninth and the superior ganglion of the tenth cranial nerves.

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nerves and are carried with them for variable distances *before* passing through communicating branches to various cranial or spinal nerves, for example, through connexions between the internal carotid plexus and the *trigeminal*, *glossopharyngeal* and vagal ganglia and through the greater superficial petrosal nerve to the facial ganglion. It has been claimed, however, that a proportion of the afferent fibres descend in the cervical sympathetic trunks or vertebral plexuses to enter the upper *thoracic region* of the cord. Other vascular afferents in the head and neck, as in other areas such as the parietes and limbs, are contained in very slender branches given off by various cerebrospinal nerves to vessels in their vicinity, for example, the arteries in the areas supplied by the external carotid artery receive such filaments from nearby branches of the trigeminal nerve.

The vascular afferents carry impulses concerned with vascular, glandular and muscular activities, and they also transmit certain pain fibres from both visceral and parietal structures.

Muscular, osseous and articular branches

Very delicate strands are supplied to adjacent muscles, bones and joints. They may pass to these structures directly from the ganglion, *via* plexuses surrounding the vessels supplying them, or in filaments given off other branches of the ganglion. Similar branches are contributed by all the other ganglia of the sympathetic trunks to neighbouring muscles, bones and joints and they will not be mentioned separately in subsequent sections.

The middle cervical ganglion

This is small (Fig. 9) and inconstant and cannot be recognized as a distinct entity in 20–25 per cent of subjects, although in such cases two or more small nodules may exist in the sympathetic trunk between the superior and inferior ganglia—above, below or at the same level as that normally occupied by the middle ganglion. The middle ganglion, or group of ganglia, corresponds to fused fifth and sixth ganglia and sometimes it may include the whole or parts of the fourth or seventh ganglia.

When a single ganglion exists it usually lies anterior to the transverse process of the sixth cervical vertebra, just above or in front of the inferior thyroid artery, or less often behind this vessel. It varies in shape, being fusiform, rounded, waisted or star-shaped.

The sympathetic trunk between the middle and inferior ganglia is seldom or never single. In the simplest arrangement there are two cords; the antero-medial one forms a loop, the ansa subclavia of Vieussens, which encircles the subclavian artery (Figs. 9, 10 and 11) lying in close relationship to the suprapleural membrane (Sibson's fascia); the postero-lateral cord often has a small ganglion upon it, the vertebral ganglion (Fig. 9) which usually lies antero-lateral to the vertebral artery, and the cord often splits to embrace the vertebral artery. There are many variants, such as duplication or triplication of the loops around the subclavian or vertebral arteries, and attachment of their upper ends to the vertebral rather than to the middle ganglion.

Like the superior ganglion, the middle cervical ganglion has communicating, visceral and vascular branches, and others which supply locomotor structures.

Communicating branches

The middle ganglion contributes grey rami communicantes to the fifth and sixth and sometimes also to the fourth or seventh cervical nerves. It sends one or two filaments to the vertebral plexus, and occasionally direct connexions exist between it and the vagus, phrenic and recurrent laryngeal nerves.

Visceral branches

These are supplied to the thyroid and parathyroid glands which lie alongside the inferior thyroid artery, and they communicate with the cardiac, pharyngeal, recurrent

and external laryngeal nerves. The cardiac branch of the ganglion (page 75) is usually large and often unites with the corresponding superior cervical cardiac branch or with cardiac branches of the vagus. Several very fine branches can be traced to the oesophagus and trachea, and in one specimen two filaments from the opposite middle ganglia joined directly in the midline behind the oesophagus.

Vascular branches

Vascular branches help to innervate the common carotid, inferior thyroid and vertebral arteries and the jugular veins.

Vertebral ganglion

The vertebral ganglion (ganglion intermédiaire) (Figs. 9 and 11) is also inconstant. It usually lies antero-lateral to the vertebral artery on one of the nerve loops surrounding that vessel and probably corresponds to fused portions of the sixth and seventh cervical ganglia. Thus, it represents a lower detached element of the middle cervical ganglion, or more often the upper element of an inferior cervical ganglion.

Any of the lower branches of the middle or the upper branches of the inferior cervical ganglia may arise from the vertebral ganglion, and it always supplies filaments which unite with the corresponding branches of the inferior cervical ganglion to form the vertebral plexus. This plexus surrounds and supplies the artery as it ascends through the foramina transversaria to enter the skull. It receives reinforcements from both the middle and superior cervical ganglia and gives off subsidiary plexuses to the branches of the vertebral and basilar arteries.

The inferior cervical ganglion

This corresponds to the (seventh) and eighth ganglia and in 75–80 per cent of subjects it is fused with the first or even the second thoracic ganglia to constitute the stellate ganglion. As this is the commonest arrangement it is selected for description.

Stellate ganglion

The stellate ganglion is intermediate in size between th [illegible] middle ganglion was described in connexion with that ganglion. It lies opposite the space between the last cervical transverse process and the neck of the first rib, and behind the vertebral artery, the first part of the subclavian artery (relationship less close on left than on right side) and the pleura. As it lies on the neck of the rib it is medial to the superior intercostal artery and its vena comitans, and immediately lateral to these vessels is the anterior primary ramus of the first thoracic nerve passing upwards to join the brachial plexus.

Its branches may be classified under the same headings as before, and again to save space the muscular, articular and osseous branches will not be described (*see* page 68).

Communicating branches

The stellate ganglion sends grey rami communicantes to the eighth cervical and first thoracic nerves [illegible] thoracic nerves are interconnected near their origins by inconstant branches which lie

in front of the corresponding ribs and which contain efferent or post-ganglionic fibres derived from grey rami connected with these nerves. When these interconnexions are present they provide alternative channels whereby sympathetic efferents may reach the first thoracic nerve and the brachial plexus, and they have been blamed for some of the failures following cervico-thoracic or stellate ganglionectomies; other possible causes of failure following sympathectomies are mentioned on pages 64-65.

The stellate ganglion receives white rami communicantes from the first and occasionally from the second thoracic nerves, and of course pre-ganglionic fibres from the second or third nerves could reach it through the independent connexions between the first two or three thoracic nerves described by Kuntz (1949).

The ganglion invariably communicates with the phrenic nerve and almost constantly with the vagus nerve or its recurrent laryngeal branch, and fine direct interconnexions sometimes exist between the ganglia on opposite sides, although these are very uncommon.

Visceral branches

These are supplied to the cardiac (page 76) and pulmonary (page 77) plexuses, and also to the dome of the pleura. It helps to innervate the trachea and oesophagus and, perhaps, the thyroid; in infants filaments have been traced to the thymus.

Vascular branches

Vascular branches derived from the ganglion itself and from the ansa subclavia supply the subclavian artery and are distributed with its branches. Others help in the formation of the common carotid and inferior thyroid plexuses, but branches to the great veins in the region are very infrequent and seldom seen even in micro-dissections. The terminal filaments on the subclavian artery extend to the proximal part of the axillary artery, but the arteries of the upper limb beyond this point are supplied by offshoots from neighbouring nerves which carry sympathetic in addition to somatic fibres. These vascular fibres are mainly efferent, although a proportion are afferent, and they lie mainly in the lower trunk of the brachial plexus and then in the median and ulnar nerves. Pressure on these fibres by cervical ribs has been cited as a cause of vasomotor and other disturbances in the upper extremity. A vertebral branch or branches run upwards behind the artery and, along with reinforcements from the other cervical ganglia, form the vertebral plexus (page 69).

The blood supply of the cervical ganglia

Surgeons performing sympathectomies occasionally encounter troublesome haemorrhage, even when every precaution has been taken to avoid injuring neighbouring vessels. Few realize that the ganglia themselves have a surprisingly good blood supply (Patterson, 1950).

The superior ganglion receives a constant supply from the ascending pharyngeal artery and inconstant contributions from the superior thyroid and the ascending cervical branch of the inferior thyroid arteries. A supplementary supply is occasionally derived from the occipital and internal carotid arteries.

The middle ganglion has a constant supply from the inferior thyroid artery, and the vertebral ganglion (ganglion intermédiaire) also receives twigs from this vessel. In addition both may receive minute direct branches from the thyro-cervical and costo-cervical trunks.

The inferior ganglion, whether separate or incorporated in the stellate ganglion, receives a supply from the inferior thyroid and mediastinal branches of the thyro-cervical trunk, and also from the superior intercostal artery. An inconstant supplementary supply from the vertebral artery has been described.

The Thoracic Part of the Sympathetic System

This comprises the thoracic portions of the sympathetic trunks and their branches, and the cardiac, pulmonary and oesophageal plexuses which are mixed structures, containing elements of both parts of the autonomic system.

The thoracic parts of the sympathetic trunks

The ganglia in this region show an evident segmental distribution (Fig. 10), although twelve ganglia are seldom present. More often there are eleven, because the first is often fused with the inferior cervical to form a stellate ganglion; it is uncommon to find less than ten. Occasionally small nodules exist on the portions of the trunk between adjacent ganglia, but intermediate ganglia in the rami communicantes (*see* page 65) are found less often than in the cervical and lumbar regions (Wrete, 1950).

They lie in front of the heads of the ribs, immediately behind the costal pleura in the endothoracic fascia, but the lower two or three ganglia incline forwards on the sides of the vertebral bodies as each trunk disappears beneath the medial arcuate ligament (medial lumbocostal arch), or between this ligament and the lateral margin of the diaphragmatic crus, to become continuous with the lumbar portion of the sympathetic trunk. The intercostal vessels and nerves are usually behind the trunks, but occasionally one or more may pass in front; and the superior intercostal arteries, which supply the first two spaces on each side, run downwards on the lateral sides of their upper parts. On the right side the azygos vein is antero-medial to the trunk and separated [illegible]

ship to the trunks, although their splanchnic branches are in close proximity to the thoracic duct on the right and the descending aorta on the left side in parts of their courses.

The ganglia are flattened, triangular or irregular swellings and do not vary much in size like those in the cervical region, although the first ganglion is usually larger and often partly or completely fused with the inferior cervical to form the stellate ganglion. The lowest ganglia are sometimes smaller or more elongated than the others. The intervening portions of the trunks are generally single, with occasional duplication or triplication between adjoining ganglia. Between the lower two or three ganglia the interganglionic portions are longer and more slender and may easily escape notice during operation or dissection unless they are tensed by traction on the more conspicuous ganglia.

The thoracic trunks give off the usual communicating, visceral, vascular, muscular, osseous and articular branches.

Communicating branches

Each ganglion receives white rami and contributes grey rami to the adjacent spinal nerves, and in this region some are of the mixed type. One to four rami are attached to each ganglion and they do not necessarily all pass to the nearest thoracic nerve, as communications with the nerves immediately above or below are fairly common. [illegible]

retro-pleural nerve networks which are formed by almost microscopic offshoots from all the adjoining somatic and autonomic nerves.

In one case a direct communication was detected between the right sympathetic trunk and right half of the upper part of the oesophageal plexus, and there are many vagal and sympathetic communications in the visceral plexuses and through interconnexions between the oesophageal plexus and the thoracic splanchnic nerves.

Visceral branches

These are supplied to the heart and pericardium, lungs and pleura, trachea and bronchi, oesophagus, thymus and to the abdominal viscera through the splanchnic branches.

Thoracic cardiac nerves.—The thoracic cardiac nerves are dealt with on page 76.

The pulmonary branches.—These are discussed on page 77.

Oesophageal and tracheal filaments.—The oesophageal and tracheal filaments in the upper thorax are often conjoined partly or completely with cardiac and pulmonary filaments, although a few direct strands can always be traced from the trunks to the oesophagus. The oesophageal filaments in the lower thorax are mainly derived from the superior thoracic (greater) splanchnic and para-aortic nerves and they enter the oesophageal plexus.

Thymic branches.—These are infrequent and have only been seen in a few dissections of infants as offshoots from the upper thoracic cardiac nerves.

Branches to abdominal viscera.—The chief branches to the abdominal viscera are the splanchnic nerves, but other fibres may be conveyed through the oesophageal and aortic plexuses, and in the inconstant para-aortic nerves.

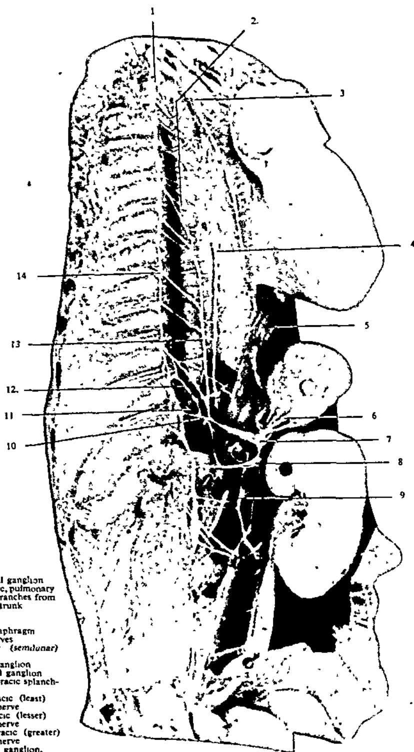
The splanchnic nerves.—These have been classified as highest, greater, lesser and least, but these are unsatisfactory terms. They are not the only splanchnic nerves, so it is advisable to call them thoracic splanchnic nerves; the existence of the highest splanchnic nerve or "ramus splanchnicus supremus" of Wrisberg is very doubtful, and it will not be considered further here; and the sizes of the three splanchnic nerves do not always correspond to their usual descriptions. Preferable terms are superior (greater), middle (lesser) and inferior (lowest or least) thoracic splanchnic nerves.

The superior thoracic (greater) splanchnic nerve.—This is almost invariably the largest of the three and in only 1 of 59 consecutive dissections was it equalled in size by the other splanchnic nerves. As a rule it arises by 3–4 larger and an inconstant number of smaller roots from the (fifth) or sixth to the ninth or (tenth) thoracic [illegible] (Fig. 10), but in about 15 per cent of cases the upper roots originate [illegible] 19), or they are connected to higher ganglia by a [illegible] the upper main root of the nerve (Fig. 10). It is believed that fibres from the nerve ascend in the sympathetic trunk to the level of the first or second ganglia. The various roots pass obliquely forwards, inwards and downwards across the sides of the thoracic vertebral bodies, lying antero-external to the adjacent portions of the intercostal vessels and immediately behind the parietal pleura, and they unite to form a nerve of considerable size, the superior thoracic (greater) splanchnic nerve. On the right and left sides they are near the azygos and hemiazygos veins respectively, and not far away from the thoracic duct and descending aorta. Each nerve pierces the homolateral diaphragmatic crus and on entering the abdomen it becomes somewhat flattened before dividing into short branches which end in the semilunar and aorticorenal ganglia of the coeliac plexus or in the numerous branches interconnecting them (Figs. 10, 15 and 16).

In its course through the thorax the superior nerve communicates with the oesophageal and aortic plexuses, and in the abdomen it sends direct filaments to the suprarenal and occasionally to the renal plexuses, and on the left side to the gastro-oesophageal junction. Just above or below the diaphragm the superior and middle thoracic splanchnic nerves are interconnected by a branch of variable size.

Apart from the few minor variations already mentioned, marked departures from the arrangement described are uncommon. One other is worth passing reference—the fusion of all three thoracic splanchnic nerves into a short common trunk, which splits on entering the abdomen into a larger branch for the coeliac plexus and a smaller branch for the renal plexus (Fig. 19).

A small ganglion, or collections of ganglion cells, exist in this splanchnic nerve, or



1 Inferior cervical ganglion
2 Thoracic cardiac, pulmonary and aortic branches from sympathetic trunk
3 Vagus nerve
4 Thoracic duct
5 Cut edge of diaphragm
6 Suprarenal nerves
7 *Right coeliac (semilunar)* ganglion
8 Aorticorenal ganglion
9 Posterior renal ganglion
10 Conjoined thoracic splanchnic nerves
11 Inferior thoracic (least) splanchnic nerve
12 Middle thoracic (lesser) splanchnic nerve
13 Superior thoracic (greater) splanchnic nerve
14 Sixth thoracic ganglion.

The inferior cervical sympathetic cardiac nerves usually consist of a variable number of filaments derived from the stellate ganglion and ansa subclavia, a single nerve being less common. They sometimes remain separate throughout or they may unite with each other or with other cardiac nerves before entering the cardiac plexus.

The thoracic cardiac nerves are slender and originate from the second to the fourth or fifth ganglia inclusive. They are often combined with pulmonary and oesophageal filaments and then the nerves split into small twigs before ending in the cardiac or pulmonary plexuses or in the oesophagus.

The various cardiac nerves form the cardiac plexus (Figs. 9 and 11) and in it they lose their individual identities, if they have not done so already through fusion with other nerves, but in some lower animals the right and left groups of nerves remain separate and are distributed mainly to the corresponding sides of the heart.

Dissection of the cardiac plexus is difficult, and judging from the variety of descriptions and illustrations supplied by different writers it must present numerous variations. However, there is agreement about the chief points. Several small ganglia exist in the plexus and the largest and most constant lies below and to the right of the aortic arch, between the tracheal bifurcation and the division of the pulmonary trunk. From this ganglion offshoots pass towards the origins of both coronary arteries. Along with filaments from other parts of the plexus they form plexuses around the coronary arteries which are distributed with these vessels, the right chiefly to the right atrium and ventricle and the left mainly to the left atrium and ventricle. Other very fine branches from the plexus pass directly to adjacent parts of the heart, aorta, pericardium, pleura, superior vena cava and pulmonary vessels.

All the cardiac nerves contain both afferent and efferent fibres, with the exception of the branches derived from the superior cervical ganglia.

The afferent fibres have their cell stations in the inferior ganglia of the vagi and in the dorsal root ganglia of the upper thoracic nerves. There are numerous sensory end-organs (pain, pressure, chemoreceptor and so on) in the wall of the heart, in the pericardium, and in the adventitial plexuses of the coronary arteries and of the ascending aorta and other great vessels. Many of the afferent vagal fibres from the heart, ascending aorta and great veins are concerned in pressoreceptive and chemoreceptive reflexes which depress cardiac activity and in some animals they are aggregated in a separate vagal component, the depressor nerve. Afferent pain fibres from the heart and aorta are conveyed mainly or entirely through the thoracic sympathetic cardiac nerves and may be interrupted by chemical or surgical destruction of the stellate and upper four pairs of thoracic ganglia, or by division of the upper five pairs of thoracic dorsal spinal roots—established procedures for the relief of anginal pain.

The parasympathetic fibres arising in the dorsal vagal nucleus are intercalary or pre-ganglionic and they end by forming synapses with efferent neurones in intrinsic [illegible] tion of the coronary arteries.

The sympathetic cardiac intercalary or pre-ganglionic fibres originate from cells in the lateral grey columns of the upper 4–5 thoracic spinal segments and enter the sympathetic trunks through the corresponding white rami communicantes. Some form synapses in the thoracic ganglia, but others ascend to the cervical ganglia before relaying, and then the efferent or post-ganglionic fibres are conveyed to the heart in the various cervical and thoracic sympathetic cardiac nerves. These sympathetic efferents produce cardiac acceleration and dilatation of the coronary vessels. The upper thoracic segments of the cord are associated with the supply of the ventricles, ascending aorta and pulmonary trunk and the atrial fibres emerge through the lower part of the thoracic cardiac outflow, but it is not known whether this arrangement applies equally to afferent and efferent pathways.

It will be noted that the action of the vagus and sympathetic on the coronary arteries is the reverse of that produced in most other vessels. From the functional viewpoint this is essential because increased cardiac activity must normally be associated with increased blood flow, and both are produced by sympathetic activity. The explanation may lie in the production of differing types of adrenaline-like substance; and there is suggestive evidence that sympathetic stimulation may produce vasodilatation rather than vasoconstriction in some other structures in accordance with the local needs of the part.

The intrinsic cardiac ganglia

These ganglia are minute and are found mainly in the atria and interatrial septum and near the roots of the great vessels They lie in the sub-epicardial connective tissue and parasympathetic (vagal) fibres form synapses within them. In man and most mammals they are scanty in number or absent in the ventricles.

Pulmonary plexuses

The pulmonary plexuses (Figs. 9, 10 and 11) are constituent parts of the lung roots and consist of large posterior and smaller anterior parts. As each vagus nerve reaches the dorsal aspect of the homolateral lung root it gives off 3–4 larger and many smaller branches which pass obliquely and transversely outwards to enter the lung; they unite with fine offshoots from the nearby cardiac nerves and plexus and with pulmonary filaments from the first or second to sixth or seventh thoracic ganglia, and these together constitute the posterior pulmonary plexus. Several small vagal branches run over the upper border of the lung root and are joined by pulmonary filaments from the cardiac plexus to form the anterior pulmonary plexus. These plexuses give off numerous filaments which form delicate plexuses around the pulmonary vessels and bronchi and are distributed with them throughout the lung, the terminal fibres extending as far as the visceral pleura Small ganglia are present within the plexuses, especially near the main bronchi, in which the vagal intercalary and efferent neurones form synapses.

The parasympathetic supply produces bronchoconstrictor and secretomotor effects and the sympathetic fibres are bronchodilator. Their respective effects on the pulmonary vessels are as yet undecided, but from the somewhat contradictory evidence available it appears that the sympathetic pulmonary vascular supply is predominantly vasoconstrictor and that the vagi, and probably the sympathetic nerves also, contain some vasodilator fibres.

Afferent fibres from the bronchi and bronchioles, lung parenchyma, visceral pleura and pulmonary vessels are carried in both vagal and sympathetic pathways. Those concerned with bronchial and chemoreceptor reflexes are probably carried in the vagi, and those from the visceral pleura in the pulmonary branches from the upper thoracic sympathetic ganglia and the dorsal roots of the corresponding spinal nerves.

The oesophageal plexus

This is described on pages 49 and 53 and the oesophageal filaments from the thoracic sympathetic trunks on page 72.

THE ABDOMINAL PART OF THE SYMPATHETIC SYSTEM

This comprises the lumbar portions of the sympathetic trunks and their branches, the coeliac and other plexuses overlying the aorta, and numerous subsidiary visceral and vascular plexuses. It must be emphasized again that these autonomic plexuses contain both sympathetic and parasympathetic elements.

ganglia, but careful dissection and microscopic examination reveal that the two coeliac ganglia are often less solid than they appear, and that they consist of smaller ganglionic masses embedded in a mass of connective tissue and nerve fibres. It is usually possible to differentiate the coeliac (semilunar), aorticorenal and superior mesenteric ganglia described by some older anatomists, besides other smaller unnamed ganglia. All these ganglia are closely interconnected by numerous bundles of nerve fibres.

The coeliac or semilunar ganglia are irregularly *quadrilateral* or *fusiform* in shape and greyish-red in colour. They may readily be mistaken for large lymph glands or dense connective tissue. Sometimes they show knob-like excrescences, and some writers have compared them to stars because of the numerous branches radiating from a central mass. Despite their alternative designation they are seldom semilunar. Each ganglion lies between the corresponding suprarenal gland and the root of the coeliac artery.

The aorticorenal ganglia may be regarded as the detached lower and outer portions of the coeliac ganglia, to which they are always united by one or more thickish bands containing nerve fibres and ganglion cells. They are intermediate in size between the coeliac and superior mesenteric ganglia and are fusiform or irregular in shape. Sometimes one or both may be represented by 2–3 smaller ganglia arranged in a rough circle or in a row in the regions normally occupied by the larger ganglia. Occasionally the coeliac and aorticorenal ganglia are fused and form a crescentic or reniform mass, and the term semilunar was, perhaps, applied originally to a ganglion of this type. In about two-thirds of cases the aorticorenal ganglia are situated above the level of the renal arteries, in the angle between them and the aorta. In the remainder the ganglion on one or both sides lies antero-superior or anterior to the renal artery, especially if this vessel is duplicated, with the extra artery lying at a higher level than normal. Their position and connexions suggest a close connexion with renal innervation, but they are also connected with the superior mesenteric and intermesenteric nerves by a variable number of branches.

The superior mesenteric ganglion (*or ganglia*) is less constantly present, and whereas the coeliac and aorticorenal ganglia are paired structures, this ganglion is often single. It lies on the aorta just above, or occasionally below, the root of the superior mesenteric artery, and is incorporated in the commencement of the superior mesenteric plexus.

Ending in the coeliac plexus are the main parts of the superior (pages 72–74) and middle (page 74) thoracic splanchnic nerves; the coeliac division of the posterior vagal trunk (pages 53 and 58) and offshoots from the anterior vagal trunk (page 53); the para-aortic nerves (page 74); and twigs from the phrenic nerves. They send direct filaments to some adjacent viscera, but most of their branches accompany arteries arising from the upper part of the abdominal aorta.

The coeliac plexus is continuous below with the intermesenteric plexus of nerves which in turn is continuous with the superior hypogastric plexus. These are all pre aortic in position; they receive the various thoracic and lumbar splanchnic nerves, the coeliac division of the vagus above and perhaps contributions from the pelvic splanchnic nerves below; and they act as parent plexuses for the numerous subsidiary plexuses distributed to the abdominal viscera. The coeliac plexus has already been described and an account of the intermesenteric and superior hypogastric plexuses will also be given before discussing the branches supplied by all three plexuses.

The intermesenteric nerve plexus

This plexus is sometimes called the pre-aortic or abdominal aortic plexus, but these terms are misleading as the coeliac and superior hypogastric plexuses are also pre-aortic and abdominal. The intermesenteric nerves lie on the anterior and antero-lateral aspects of the aorta between the origins of the mesenteric arteries (Figs. 15,

16 and 17). Their size and number vary inversely, but usually 4–12 are present, and often the outermost nerves are lateral to the aorta and do not rest directly upon it. On the left side this may be significant because of the proximity to the lumbar sympathetic trunk and the possible confusion between them at operation.

They are continuous above with the coeliac plexus Below the central fibres mainly form the plexus around the inferior mesenteric artery and the outer fibres pass downwards into the superior hypogastric plexus.

They receive the first and second lumbar splanchnic nerves and give off renal, testicular or ovarian, ureteric, pancreatic, duodenal, aortic and vena caval branches.

The superior hypogastric plexus

The superior hypogastric plexus is often called the pre-sacral nerve or hypogastric plexus. The alternative terms are both unsatisfactory: a single nerve is seldom found; the plexus is pre-lumbar rather than pre-sacral, it does not lie entirely in the anatomical hypogastric region; and the term hypogastric is applied to the pelvic plexus by continental writers.

It extends from the level of the lower border of the third lumbar vertebra to the middle of the first sacral vertebra, where it ends by dividing into the right and left hypogastric nerves or plexuses (Figs. 15, 16 and 17). It is situated anterior to the lower abdominal aorta and its bifurcation, the median sacral vessels, and the last two lumbar and first sacral vertebrae and their intervening discs. The parietal peritoneum is an immediate anterior relation and the plexus can often be seen shining through in persons with little extraperitoneal fat, but the two are not closely adherent. The root of the pelvic (sigmoid) mesocolon and the contained superior rectal vessels lie to its left side below. The plexus is seldom exactly median in position.

As mentioned above, the outer intermesenteric nerves apparently take little part in the formation of the inferior mesenteric plexus and pass directly downwards into the superior hypogastric plexus. However, the lower part of the origin of the inferior mesenteric plexus is always interconnected to the upper part of the superior hypogastric plexus, and in addition these two plexuses are sometimes connected by oblique branches which bridge across the interval between the left side of the superior hypogastric plexus and the inferior mesenteric plexus not far from its origin; these last may contain parasympathetic fibres derived from the pelvic splanchnic nerves (*see* page 59).

The plexus consists of a vertical flattened band of intercommunicating nerve bundles, wider below than above. There are two or three or more main bundles, with smaller oblique anastomotic fibres. As a rule the constituent bundles are not widely separated above and do not extend much, if at all, beyond the margins of the aorta, but below the plexus broadens out before dividing into the two hypogastric nerves. Occasionally the bundles are more spread out and are found straggling downwards across the whole inter-iliac trigone between the diverging common iliac arteries.

The third and fourth lumbar splanchnic nerves end in this plexus, and it contributes to the innervation of the kidney, testis or ovary, ureter, descending colon, aorta and common iliac arteries; and through the hypogastric nerves it supplies a large proportion of the sympathetic fibres for pelvic structures.

Branches of distribution of the coeliac, intermesenteric and superior hypogastric plexuses

They contribute branches directly to several viscera, but mostly they give off subsidiary plexuses which are distributed with the various branches of the abdominal aorta.

The phrenic plexuses (Fig. 15) accompany the phrenic arteries, communicate with terminal twigs of the phrenic nerves, and contribute filaments to the suprarenal glands. Both may send offshoots to the gastro-oesophageal junction and liver.

The coeliac plexus (pages 79–80) supplies numerous visceral branches (Figs. 15, 16 and 17). Some pass directly to adjacent viscera such as the suprarenal, kidney, duodenum and pancreas, but most accompany the branches of the coeliac and superior mesenteric arteries. The visceral nerves accompanying the vessels do not form regular net-like structures closely embracing them, although the actual adventitial plexuses are arranged in this way. The main visceral nerves are variable in size and number and lie more or less parallel to the vessel, either in contact with it or separated by a distinct interval. They are interconnected by occasional finer, oblique filaments, and resemble a very open network formed by threads of different thickness and with meshes of varying size. Because of the anatomical arrangement, in most cases complete denervation of a viscus will not be produced by removal of a cuff of tissue immediately surrounding its main artery.

The coeliac artery divides into left gastric, hepatic and splenic branches, and the superior mesenteric artery into inferior pancreatic-duodenal, jejunal and ileal, and colic branches. These subdivide in turn and all are accompanied by nerves derived from the coeliac plexus.

The left gastric plexus (Figs. 13 and 14) consists of 1–4 filaments which lie near the artery and supply twigs to the cardiac end of the stomach. Others run along the lesser curvature to supply adjacent parts of the stomach and communicate with the right gastric plexus and gastric branches of the vagus.

The hepatic plexus (Fig. 13), like all the others arising from the coeliac plexus, may contain both sympathetic and parasympathetic (vagal) afferent and efferent fibres. It gives off secondary plexuses along the right gastric, gastro-duodenal and cystic arteries.

The fibres passing to the liver lie in the free margin of the lesser omentum and are usually arranged in two discrete groups, one anterior to the hepatic artery and the other posterior to the portal vein, although in some specimens filaments surround the vessels on all sides. Scanty anastomoses exist between adjacent filaments and between the anterior and posterior groups, and the latter connexions often form curved loops. The groups of fibres subdivide above and accompany the corresponding branches of the hepatic artery and portal vein into the liver. Before doing so they give off two or more hepatogastric nerves which pass to the lesser curvature of the stomach and the cardiac orifice between the layers of the lesser omentum. They also supply fibres to the common bile duct and these are derived mainly from the anterior group of hepatic filaments.

The cystic plexus is minute and innervates the gall-bladder. Near the commencement of the artery only one nerve is usually found arising from the filaments accompanying the right branch of the hepatic artery, but it subdivides as it proceeds towards the gall-bladder and communicates with a cystic branch from the vagus (page 53).

The right gastric nerves (Fig. 14) are very fine and supply the upper parts of the pyloric region and right end of the lesser curvature.

The gastro-duodenal plexus (Fig. 14) consists of 2–3 filaments which accompany the artery between the first part of the duodenum and the neck of the pancreas, supplying fibres to both structures and to the adjacent part of the common bile-duct. When the artery subdivides into its superior pancreatico-duodenal and right gastro-epiploic branches the nerves also subdivide and are distributed to the second part of the duodenum, the termination of the common bile-duct, the head of the pancreas, the greater curvature of the stomach and the greater omentum. Direct interconnexions between the gastro-duodenal and renal and spermatic plexuses have been found in several dissections.

The splenic plexus (Fig. 14) consists of 4–6 filaments which follow the artery more or less closely to its termination in the spleen, and which send extensions along its pancreatic, short gastric and left gastro-epiploic branches to supply the structures

indicated by their names. Another filament from the plexus may curve upwards to supply the fundus of the stomach, and one of its terminal filaments communicates with a gastric branch of the posterior vagal trunk.

The innervation of the stomach may now be summarized. It receives branches from the anterior and posterior vagal trunks (page 53), and from the right and left gastric, hepatogastric, right and left gastro-epiploic and short gastric nerves, besides occasional direct filaments from the coeliac and splenic (page 82) plexuses. The gastro-oesophageal junction may receive additional filaments from the phrenic plexuses (page 81), the left phrenic nerve, the oesophageal plexus (pages 53 and 72), and from the terminal part of the left superior thoracic (page 72) or first lumbar (page 78) splanchnic nerves, although these filaments cannot all be demonstrated in the same specimen. From this catalogue it will be evident that local denervation of any particular part of the stomach is a tricky business.

The sympathetic supply to the stomach diminishes peristalsis and secretion, contracts the pyloric sphincter and produces vasoconstriction; and the vagal supply produces opposite effects. The sympathetic pre-ganglionic fibres emerge through the sixth or seventh to ninth or tenth ventral thoracic nerve roots and relay in the coeliac plexus; the corresponding parasympathetic fibres reach the stomach through the vagi and relay in the myenteric and submucous plexuses (page 58). The afferent pain fibres enter the cord through the sixth to ninth dorsal thoracic spinal roots; and other afferents may also follow this route, but those concerned with feelings of nausea and hunger travel in the vagi.

The superior mesenteric plexus (Figs. 15 and 16) is the largest derivative of the coeliac plexus and is a continuation of its lower part. At their origin the constituent filaments are more numerous along the anterior surface of the artery and all are interconnected by the usual oblique branches. The main plexus divides into secondary plexuses which surround and accompany the inferior pancreatico-duodenal, jejunal, ileal, ileocolic, right colic and middle colic branches of the artery, and these supply all parts of the intestinal tract and their vessels from the terminal half of the duodenum to near the left colic (splenic) flexure, a few small filaments enter the head of the pancreas.

The nerve and vascular patterns do not coincide exactly and many of the nerves pass straight outwards to the gut without any arcade formation, although small offshoots do accompany all the vessels. One almost constant loop lies along the inner margin of the inferior mesenteric vein and interconnects the origins of the superior and inferior mesenteric plexuses.

The inferior mesenteric plexus (Figs. 15, 16 and 17) is formed mainly by branches from the intermediate intermesenteric nerves, and by smaller contributions from the outer nerves and from adjacent lumbar splanchnic nerves. Its origin is always connected to the upper and central parts of the superior hypogastric plexus, and parasympathetic fibres from the pelvic splanchnic nerves may reach it through this plexus (page 59). Sometimes its origin is connected to the left outermost intermesenteric nerve by a loop from which filaments pass to the renal and spermatic plexuses. A ganglion may exist just above the root of the inferior mesenteric artery, but more often minute, discrete ganglia are found both above and below the vessel or scattered in the proximal part of the plexus. Secondary plexuses are given off around the superior and inferior left colic and superior rectal arteries, and they supply the gut from the end of the transverse colon to the lower rectum, communicating above with corresponding branches on the middle colic artery and below with rectal branches from the inferior hypogastric plexus. Many filaments supplying the gut often run more or less independently and do not accompany the vessels closely.

The nerves which are believed to carry the parasympathetic fibres to the distal colon were described on pages 59–60.

The suprarenal plexuses.—Relative to their size, the suprarenal glands have a more profuse innervation than any other viscus. Numerous filaments pass outwards to each gland from the homolateral coeliac ganglion and superior thoracic splanchnic nerve and these are spread out and not closely aggregated around the vessels (Figs. 15 and 20). The phrenic nerves always send twigs to the glands and they receive occasional contributions from the splanchnic ganglion (page 74), or from the middle thoracic splanchnic nerve and first lumbar ganglion. The lower suprarenal and upper renal filaments are interconnected by one or more loops.

The renal plexuses.—The renal innervation is also profuse and the nerves arise from multiple sources (Figs. 10, 15, 16, 17 and 20). They are derived from the coeliac plexus, the thoracic and upper lumbar splanchnic nerves, the upper ends of the intermesenteric nerves, and from the lower ends of these same nerves or the superior hypogastric plexus or from both. The renal coeliac derivatives come from the coeliac and aorticorenal ganglia and lie along the upper border of the renal artery; they contain sympathetic and probably vagal fibres. The superior thoracic splanchnic nerve occasionally, and the middle thoracic splanchnic nerve almost invariably, send filaments to the aorticorenal ganglion or renal plexus, while the inferior thoracic and part of the first lumbar splanchnic nerves end in the posterior part of the plexus. The upper renal branches from the intermesenteric nerves run directly to the renal hilum, but those from the lower ends of these nerves or from the superior hypogastric plexus run obliquely upwards and outwards to enter the infero-lateral part of the plexus and are mainly distributed to the pelvis and upper ureter (*see also* pages 58–60).

The various renal nerves unite in a plexiform fashion around the renal artery and this plexus divides into secondary plexuses which accompany the arterial branches into the kidney. Ganglia of varying size occur in the plexus. The largest and most constant lies behind the renal artery and is termed the posterior renal ganglion.

There is a prevalent idea that the renal sympathetic efferent supply is purely vasomotor, but there is no doubt that nerve fibres end in intimate relationship to the tubules and glomeruli and these must have some other, at present unknown, function. The effects produced by the parasympathetic supply are uncertain. Very little is known about renal afferents, but those transmitting pain impulses enter the cord through the lowest two thoracic and first or second lumbar dorsal nerve roots. Brief notes on the intercalary and efferent sympathetic neurones are given on page 64.

The ureteric and spermatic nerves arise both from abdominal and pelvic sources and they are described on pages 88–89.

The lumbar plexuses are most evident around the proximal parts of the lumbar arteries because they contain the branches from the sympathetic trunks to the aortic plexus. Beyond the levels of the sympathetic trunks the periarterial nerves are much less profuse, and it is uncertain whether any of them extend outwards from the great pre-vertebral autonomic plexuses. Perhaps they are derived only from the adjacent sympathetic trunks.

The median sacral plexus.—The upper fibres come from the superior hypogastric plexus and as the median sacral artery passes downwards its plexus is supplemented by filaments from the sacral sympathetic trunks and their interconnexions.

The iliac arterial plexuses

The common iliac plexuses are continuous above with the abdominal aortic plexus and below with those on the external and internal iliac arteries. Filaments may pass directly to the common iliac artery from the superior hypogastric plexus, the adjacent parts of the homolateral lumbar or sacral sympathetic trunk, and the last lumbar splanchnic nerve, but while two of these supplies often coexist, all three have never been found in the same specimen. An inconstant filament may arise from the third lumbar splanchnic nerve and runs do[illegible]ngside the inf[illegible] vena cava or aorta to



Fi[illegible]

to aid photography.

[illegible]

14 [illegible]
15 [illegible]
16 [illegible]
17 [illegible]
18 Renal branches from lower ends of intermesenteric nerves
19 Nerves to distal colon arising from inferior hypogastric plexus and hypogastric nerve

K Kidney
S Suprarenal

end in the posterior part of the common iliac plexus near its origin; when present the right and left nerves supply filaments to the vein and aorta respectively. The filament from the last lumbar splanchnic nerve or sympathetic trunk communicates with the middle ureteric or gonadal nerves, and the arterial contribution is sometimes relatively large. In several specimens it has been traced downwards as far as the thigh where it apparently ended about the femoral bifurcation; whether it has some special vasopressor or other function is unknown. A twig from the genitofemoral nerve enters the lower end of the common iliac plexus, and this filament may also communicate with the last lumbar splanchnic nerve or sympathetic trunk by a slender branch. The external iliac plexus likewise receives a genitofemoral contribution, but it appears to be mainly an extension of the common iliac plexus. The same is partly true of the internal iliac plexus, but in addition it receives direct filaments from the upper sacral ganglia and from the corresponding hypogastric nerve. Offshoots from these plexuses extend along their branches of distribution. However, the arterial plexuses of the lower extremity, like those of the upper, receive reinforcements at intervals from sympathetic fibres carried in the femoral, sciatic and obturator nerves and their branches. Knowledge of this arrangement has led most surgeons to abandon operations based on the idea that stripping of an artery near the root of a limb will produce complete denervation of the arterial tree beyond that point.

The Pelvic Part of the Sympathetic System

This comprises the sacral portions of the sympathetic trunks, the hypogastric nerves, and the inferior hypogastric plexuses. Once more it must be emphasized that the plexuses are really autonomic, containing as they do both sympathetic and parasympathetic elements.

The sacral portions of the sympathetic trunks

These are continuous above at the pelvic brim with the lumbar trunks (Fig. 16), and below they converge and end in front of the coccyx in a single small ganglion, the ganglion impar, or they may be interconnected merely by filaments with no gangliform enlargement. They lie in front of the sacrum, just medial to the anterior sacral foramina, and each contains four or three ganglia; five ganglia are rarely seen. They are smaller than the lumbar ganglia and are fusiform in shape. The interganglionic cords are seldom duplicated.

They supply the usual communicating, visceral, vascular, osseous, muscular and articular branches.

Communicating branches

Each ganglion supplies one or more grey rami communicantes to the adjacent sacral and coccygeal nerves. Their fibres enter the branches of the sacrococcygeal plexus and [illegible] joints in their [illegible]

Apart from the terminal communication, the sacral trunks are connected by [illegible] transverse filaments at higher levels.

Visceral branches

These pass to the inferior hypogastric plexus and are distributed through its branches, but direct filaments from the sacral trunk have been traced to the ureter and rectum.

Vascular branches

The vascular branches are supplied from the upper one or two ganglia to the common and internal iliac plexuses, and others pass to the median sacral plexus.

The blood supply of the sacral sympathetic trunks

The first sacral ganglia receive twigs from the superior lateral sacral and median sacral arteries. The others are supplied by the median sacral and inferior lateral sacral arteries.

The hypogastric nerves

These nerves are formed by the bifurcation of the superior hypogastric plexus (Figs. 16 and 17). They diverge and curve outwards, downwards and backwards into the pelvis, lying internal and almost parallel to the internal iliac arteries. The angle between the diverging nerves is often bridged across by delicate interlacing fibres which constitute a middle hypogastric plexus. The nerves may be single or may consist of two or more bundles with oblique anastomosing strands forming an elongated plexus. Branches are supplied to the colon, testis or ovary (pages 88–89), ureter (page 88), and vessels. Each terminates in the corresponding inferior hypogastric plexus and provides its chief complement of sympathetic fibres.

The inferior hypogastric or pelvic plexuses

These plexuses are situated one on each side of the rectum, prostate, seminal vesicles and the posterior part of the lateral wall of the bladder (Figs. 16 and 17). In the female the cervix uteri and lateral vaginal fornices replace the prostate and vesicles as medial relations, and opposite these structures part of the plexus lies in the base of the broad ligament. The great majority of the fibres entering or leaving the plexus do so through the hypogastric nerves, and many writers do not differentiate the latter as separate entities, but describe them as parts of the pelvic plexuses.

[illegible]

and tributaries of the homolateral internal iliac artery and vein, with the corresponding lymph glands, and with areas of the levator ani, obturator internus, pyriformis and coccygeus, the muscles being separated from the plexus by the parietal pelvic fascia, by a variable amount of fatty tissue, and by the vessels and lymph glands. A second distinct layer of fascia is said to intervene between the plexus and vessels, but more often than not it is rather indefinite. The sacro-coccygeal plexus and its branches lie posteriorly, and the ureter crosses the superior border from without

[illegible]

their numerous anastomoses render the accurate tracing of nerve bundles almost impossible. The main connexions are with the homolateral hypogastric nerve which joins the postero-superior angle and carries the majority of the sympathetic fibres to the plexus, but other sympathetic fibres are conveyed through filaments from the sacral portion of the sympathetic trunk. These may arise from any of the sacral ganglia or their intervening cords, but usually from the second and third, and they enter the posterior part of the plexus. The parasympathetic fibres reach the plexus through the pelvic splanchnic nerves (page 59).

According to several writers the plexus is bilaminar (some say trilaminar), consisting of an outer layer which is continuous with the pelvic splanchnic nerves and an

inner layer which is formed by a spreading out of the corresponding hypogastric nerve. Such divisions are largely artificial and of little practical importance.

Branches of distribution

Many branches from the inferior hypogastric plexus supply all the pelvic viscera and some may ascend into the abdomen to innervate such structures as the distal colon (page 59) and renal pelvis and ureter (page 60). Some nerve bundles pass directly to the organs, but the majority accompany the branches of the internal iliac artery more or less closely and so are conveyed to the pelvic viscera and genitalia. As previously stated the visceral nerves do not form intricate perivascular plexuses.

The rectal nerves, 4–8 in number on each side, detach themselves from the deep surface of the plexus, run to the rectum directly, and after coursing for short distances on the surface sink into the walls. One or two accompany the middle rectal artery and the others are separated from it. They communicate with the terminal filaments of the inferior mesenteric plexus around the superior rectal artery. Filaments from the pelvic splanchnic nerves seldom pass directly to the rectum. They usually enter the plexus first and are then distributed with its branches.

Ureteric nerves.—Each ureter receives filaments from three main sources: (1) a superior group (*see* page 84) from the lower part of the renal plexus and from the lower ends of the intermesenteric nerves or upper end of the superior hypogastric plexus; (2) a middle group from the lower end of the superior hypogastric plexus or [illegible] and (3) an inferior group from the lower end [illegible] They com- [illegible] and travel for a variable distance with nerves to these structures. The inferior branches form loops around the lower end of the ureter. All three groups may carry both sympathetic and parasympathetic fibres.

The vesical nerves are numerous and arise from the anterior parts of the plexuses and from the periureteral loops. They diverge from their origins, dividing and subdividing, and after proceeding for varying distances on the surface they sink into the lateral walls and base of the bladder, extending thereafter to every part of the viscus. In the male the basal filaments are closely associated with the prostatic and vesicular branches, and in the female with cervical and vaginal branches. Those arising from the ureteric loops are short and supply the adjacent areas of the bladder.

The prostatic, vesicular and penile nerves.—The prostatic nerves originate from the antero-inferior part of the plexus, close to the vesicular and lower vesical branches. Some enter the basal part of the gland and one or two run downwards on its lateral [illegible] urethra, and some [illegible] and bulbo-urethral glands may be conveyed along the internal pudendal arteries [illegible] their branches to the structures mentioned.

The vesicular branches are short and come from the adjacent parts of the plexuses or periureteral nerve loops. Most of the nerves enter the posterior surfaces, and one or two larger filaments extend along each vas deferens as far as the epididymis.

Testicular and ovarian plexuses.—These are derived from the same three main sources as the ureteric nerves, often arising near together, and for parts of their respective courses the nerves are united or closely interconnected (Figs. 15, 16 and 17).

The superior group arise by two or more rootlets from the renal plexus and intermesenteric nerves and may receive a direct filament from the second or th[illegible] splanchnic nerves. They coalesce to form 1–2 larger filaments whic[illegible]

corresponding testicular or ovarian artery to the testis and epididymis or ovary and uterine tube.

The middle group reach the corresponding testicular or ovarian vessels about the level of the pelvic brim. They arise by several rootlets from the superior hypogastric [illegible]

appears to supply fibres only to the epididymis and helps to innervate the vas deferens. The ovarian nerve sends filaments to the uterine tube and uterus.

The inferior group often arise from the nerve loop surrounding the lower end of the ureter or they may spring directly from the inferior hypogastric plexus. In the male the nerves accompany the vas and supply it, but with care one filament can be traced to the epididymis. The corresponding ovarian nerves, usually 3–4 in number, run up between the layers of the broad ligament, some near the uterine artery and others nearer the side wall of the pelvis. They are apparently distributed mainly or entirely to the uterus and the uterine tube, and perhaps it is wrong to call them ovarian. It has been suggested that they carry parasympathetic fibres from the pelvic splanchnic nerves to the uterine tube and uterus.

The uterine and tubal nerves are closely associated. The former arise from the anterior parts of the pelvic plexuses near their superior borders. Three to five of the lower filaments on each side enter the cervix and the upper part of the vagina, communicate with the vesical nerves, and present one or more small nodules, the paracervical ganglia, which usually lie behind the uterine arteries on the lateral sides of the cervix.

The higher uterine filaments, 2–4 in number on each side, ascend alongside the uterine arteries between the layers of the broad ligament, giving off fine twigs *en route* which sink into the uterus. Their terminal filaments help to innervate the uterine tubes, communicate with the ovarian nerves, and may extend for some distance along the round ligaments.

The uterine tubes are apparently innervated from three sources—the superior, middle and inferior ovarian nerves—although it is not certain that they do receive a supply from the first group. The inferior group lie farther out in the broad ligament than the uterine nerves, but they are always interconnected by several branches, and these anastomosing nerves are sometimes referred to as the tubo-uterine plexus.

The vaginal nerves are derived from the antero-inferior parts of the pelvic plexus, they lie near to the vaginal artery, and they are distributed to the vaginal walls and to the erectile tissue of the vestibule. The upper vaginal branches are connected with nerves supplying the lower end of the ureter, uterus (utero-vaginal plexus) and base of the bladder. As in the male, other autonomic fibres may be carried with branches of the internal pudendal artery to the vestibular bulbs, greater vestibular glands, clitoris and urethra.

The sympathetic fibres reaching the inferior hypogastric or pelvic plexuses emerge in the lower thoracic and upper lumbar white rami communicantes and the intercalary or pre-ganglionic cells are located in the lateral grey columns of the same segments of the cord; the corresponding parasympathetic cells are in the middle sacral segments and their fibres run in the pelvic splanchnic nerves. The former relay in the sympathetic trunks or in some of the pre-aortic or hypogastric ganglia; and the latter relay in ganglia near or within the viscera. Brief information about the sensory pathways that are more important from the surgical viewpoint is given on pages 42–43 and 59.

In general the sympathetic fibres inhibit peristalsis, contract involuntary sphincters

and cause vasoconstriction, whereas parasympathetic fibres produce peristalsis, relaxation of sphincters and vasodilatation. As mentioned on page 58, doubts have been expressed about the effects of the sympathetic supply on the bladder and of the parasympathetic nerves on the uterus.

(*See also British Surgical Practice*. Autonomic Nervous System—Anatomy, Vol. 1, page 452, S. Key 44.)

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BONE—ACUTE INFECTIONS

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Since the introduction of chemotherapeutic and antibiotic methods for control of acute infection it has become necessary to revise our views about the pathology of bone infection and viability. For instance, acute infection of bone should never now be fatal; it should never now cause the loss of a limb; it should never now lead to sequestration.

There are three main methods by which bone becomes infected: (1) blood-borne metastatic deposition of infected material, or of organisms, in the marrow system of the bone—acute primary haematogenous osteomyelitis, (2) involvement of bone from established blood-borne infection in the environment—for instance, the spread of infection to the tibia following infection of a haematoma or cellulitis over the tibial subcutaneous surface; and (3) infection of bone arising in connexion with an open wound—such as a compound fracture or a gunshot wound

The actual incidence of acute pyogenic infection of bone has been reduced by the introduction of antibiotic therapy for the primary lesions, such as carbuncles and boils, from which the bone infection was a metastasis. There remains one group in which the primary lesion is still very commonly overlooked—that of the infant with neonatal sepsis at the umbilicus (*see* Vol 8, page 350). In the big group of cases which used to result from open wounds of bone, infection has been almost entirely eliminated by meticulous surgery and the early use of antibiotics in the treatment of the initial wound. Infected compound fractures are therefore now a rarity.

Under this new conception of bone pathology which has been brought about by the introduction of chemotherapy and antibiotics, we may consider several types of case.

TYPES OF CLINICAL PRESENTATION

(1) The aborted case, in which there have been the signs and symptoms which we associate with acute infection of bone—redness, swelling and tenderness over the metaphysis. If penicillin therapy has been commenced very early the whole condition subsides and no radiological evidence is ever found that the bone has been involved. In fact, it is never known whether this was a bone infection or a soft-tissue infection alone, and there must be many cases in which the bone has been infected but in which evidence has not been found.

(2) A similar presentation in which, at ten days or just after, new periosteal bone is seen on the skiagram: the physical signs disappear and the bone reverts to normal within a few weeks.

(3) Bone infection in which radiographic changes are much more marked, mottled rarefaction appearing as the process resolves. The rarefied areas are viable decalcified bone, and although there may be no fever, no pain and no other physical signs this bone is weak and will need to be protected from weight-bearing to prevent pathological fracture or deformity.

(4) The case which has been clinically abortive and in which chemotherapy has ceased too soon, the result being chronic osteitis and the formation of a Brodie's abscess. It is conjecture, but I think that the next few years will see an increase in the incidence of such chronic lesions of bone unless surgeons make certain that

chemotherapy and antibiotic therapy continue until radiological examination shows a restoration of normal uniform structure, with perhaps some cortical thickening only.

(5) Finally there is the case in which resistance to penicillin therapy is absolute. This possibility constitutes the greatest danger in the modern conservative treatment of osteitis. If the causative organism is resistant to penicillin initially, then the osteitis will take the old-fashioned course and be a very serious disease leading to bone destruction. It is therefore wise to institute sulphadimidine therapy at the beginning, in case penicillin resistance is present. Further, in severe cases this very possibility of resistance may justify early surgical intervention of a minor nature, since a delay of twenty-four hours might precipitate thrombosis of the nutrient vessels and consequent necrosis of bone.

TREATMENT

Surgical

Primary operations

When a case of suspected acute infection of bone is first reviewed, the surgeon must decide whether exploration of the bone is warranted immediately. The majority of cases will not call for this, but in some there are certain features which justify intervention without delay:

(1) The presence of a localized abscess over a bone which can be easily palpated, as for instance over the tibia or scapula. Such an abscess should be aspirated and penicillin instilled before the removal of the needle; aspiration may need to be repeated.

(2) In the case of bones more deeply placed, when tenderness is great and signs in the soft tissues surrounding the bone indicate the presence of a deep abscess, aspiration should be attempted, and if this fails to reveal pus a small incision should be made and a sinus forceps inserted down to the bone. The common site for such a procedure is the lower end of the femur, a small incision being made over the lateral aspect of the lower third of the thigh just above the knee.

(3) When the whole circumference of the limb is involved in brawny induration indicating a much greater extent of bone infection. Here the bone should be approached through the appropriate incision. It is almost certain that pus will be found around the bone or deep to the periosteum. The bone should be drilled at the metaphysis.

(4) When the local physical signs are minimal but the constitutional disturbances grave, the bone should be explored by a small incision placed over the point of maximal local physical disturbance, and if the condition of the periosteum confirms the presence of infection the metaphysis should be drilled.

Except when the destruction of soft tissue and the presence of large amounts of granulation indicate otherwise, penicillin and sulphonamide powder may be placed in the wound, which should be closed by primary suture with interrupted nylon stitches.

If the abscess is found to be large and is deeply placed a small corrugated rubber drain should be placed down to it and the superficial wound left open.

Delayed primary suture

As a rule, when surgical intervention has been undertaken in the initial stage and the wound left open, it may be closed by delayed primary suture when the constitutional disturbance is passed—usually 4–5 days after the initial operation. It is in this particular respect that antibiotic therapy has altered the prognosis of acute bone infection. Instead of the life-long wide white scars which are associated with the old-fashioned osteomyelitis, there is a small inconspicuous and non-adherent surgical incision scar.



(a)



(b)

Fig. 21.—Acute neonatal epiphysitis. Neonatal staphylococcal septicaemia in 1945 with suppurative osteitis of scapula and left tibia. Two films showing the late effect of infection of the epiphyseal line No disability or growth retardation at 5 years of age.

Secondary operations

During the conservative treatment of cases which have not demanded operative intervention at an early stage, periosteal or subcutaneous abscesses may appear which will require aspiration or even open drainage. Their detection depends on the regular examination of the limb as fever very rarely occurs if the organism is sensitive to the antibiotic. The application of a complete plaster cast is therefore prohibited in the treatment of bone infection during this phase of treatment. In exceptional cases operation for the removal of sequestra or the drainage of bone abscesses may have to be undertaken.

"Pulp infection"

In digital sepsis, it is necessary to emphasize that in spite of the success of antibiotic therapy, tension-relieving incisions of the pulp are often required and should not be delayed. On the other hand, after such a pulp infection x-ray examination may show that the terminal phalanx has been disintegrated and the appearance may be such that before the days of penicillin the extrusion of a sequestrum would have been considered to be inevitable. Nevertheless, what may have been interpreted as being a sequestrum may regain its vitality and be incorporated once more into the calcified haversian system. The gaps between these islets of bone are probably filled, not by granulation tissue, but by decalcified bone which is by no means dead.

This return to apparently normal bone architecture after very extensive osteolysis is shown in Fig. 22. This particular patient had developed an infective osteitis of the metatarsus complicating a trophic ulcer.

Acute epiphysitis in infancy

As has already been mentioned, the common source of staphylococcal bone infection in infancy is umbilical sepsis. More often than not infection of the metaphysis leads to a rapid spread of infection to the epiphysis and to consequent distortion of the ossification centre. Nevertheless, even when the capital femoral epiphysis is involved complete resolution may occur. It is necessary to bear in mind the possibility of such a lesion in a baby with infection. Aspiration of the joint and, in the case of knee or hip, separation of the joint surfaces by gallows suspension are essential if normal function is to be restored (Fig. 21).

If an epiphysis, for instance the upper tibial epiphysis, has been involved in an infective process in infancy, the limb may have to be protected during the first three or four years of life by suitable splints to prevent bowing. Unequal or wedge growth of an epiphysis may to some extent be limited by the application of the principle of compression on the more rapidly growing aspect. This principle is used in control of epiphyseal growth by stainless-steel staples, but when there is infection, splints of the type used in the treatment of genu valgum or genu varum are preferable.

Chemical and antibiotic therapy

This must be started immediately and as the causative organism may not be penicillin sensitive, sulphadimidine should also be given. It is suggested that crystalline penicillin should be used in adequate dosage for the first four days. On the third day procaine penicillin (with aluminium stearate) should be commenced so that the in- [illegible]

tinued for a minimal period of six weeks after fever has subsided or until at least one month after the disappearance of any radiographic signs of rarefaction or texture irregularity.

It is not necessary to continue sulphonamide therapy once it has become apparent that the infection is under control, unless pyrexia returns, or the organism is isolated and found to be penicillin-resistant.

The author has had no experience of the use of aureomycin in bone infection.

Splintage

As already suggested, complete casts preventing regular examination of the disease site should not be used until clinical signs of activity of the infection have disappeared. A plaster gutter splint is all that is necessary.

In a baby under four years of age, when the lower limbs are involved, gallows suspension with skin traction may be advisable to diminish the risk of joint or epiphyseal damage.

When weight bearing commences (and this can begin before the complete restoration of normal bone texture) the lower limb should be supported if there has been any rarefaction.

The use of splints to prevent deformity subsequent to epiphyseal damage has already been outlined.

PROGNOSIS

The final bone structure after adequate antibiotic therapy is usually normal as to texture, and very rarely is there any appreciable sclerosis.

If there has been extensive periostitis the whole girth of the bone may be greater than that of the opposite limb and the contrasted sizes may be the only radiological evidence of past disease (Fig. 23).

Hyperaemic overgrowth in length is common, especially in the tibia. Deformity may arise from irregular hyperaemic overgrowth or partial epiphyseal destruction, but the degree of recovery towards normality is often remarkable (Fig. 23 (*d*)).

Permanent circulatory changes and restriction of joint movement may also be found if initial bone involvement has been extensive.

(*See also British Surgical Practice.* Bones—Acute and Chronic Infections, Vol. 2, page 241, S Key 66.)

BREAST—INNOCENT LUMPS

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ANATOMY

Before being able adequately to describe innocent lumps in the breast, it will be necessary briefly to review the minute anatomy of this organ. Our knowledge of this is due particularly to the work of Cheatle and Cutler (1931), from whom the ensuing description is taken. The breast consists of about twenty ducts together with their branches, ramifying throughout a fatty and fibrous tissue stroma in a radiating fashion like the spokes of a wheel. At the periphery of the breast the branches belonging to one duct overlap and interlace with the branches of adjacent ducts like the branches of a tree in a thick forest, and there are in no sense any segmental proprietary rights to a particular duct.

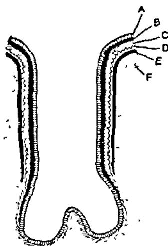


FIG 24.—The structure of a duct. A, epithelium; B, smooth muscle; C, subepithelial fibrous tissue; D, elastica, E, *smooth muscle*, F, periductal fibrous tissue (*after Cheatle*).

For our purposes interest is concentrated on the anatomy of the ducts and their terminations. Each duct divides successively into a myriad of ductules, like the twigs of a branch, and each ductule is described as ending in a number of blind tubes, five or six terminal buds being common to each. These terminal blind endings are conventionally referred to as alveoli or acini, but, as Dawson (1933) has pointed out, except in the lactating breast, they do not secrete and they should therefore be described as terminal ductules. Microscopical study of the ducts and ductules reveals five coats (Fig. 24). Lining the duct is a single, or sometimes a double, layer of columnar cells, which diminish in stature as they approach the periphery and are at this site usually described as cuboidal. Immediately adjacent to this layer are some smooth muscle fibres and a loose fibrous tissue lamina known as the sub-epithelial fibrous tissue. Next comes a layer of elastica which may "peter out" at the very end of the ductule, and which is encased on its outer surface by a tenuous layer of smooth muscle fibres. Outside the elastica and its associated muscle is the periductal fibrous tissue, tough and closely woven; it lends body to the duct and plays a pre-eminent part in many of the pathological conditions presently to be discussed.

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FIBROADENOMA

This common lesion is usually divided, both histologically and clinically, into two distinct types: the "firm" or pericanalicular fibroadenoma, and the "soft" or intracanalicular fibroadenoma, but such a distinction if applied too rigidly does not take

into account the vagaries of nature, nor her infinite variety. If we accept this classification for ease of description, and indeed nine-tenths of these cases fall comfortably into the one or the other category, we must yet bear in mind that some cases show a mixed pathology. Clinically speaking these cases are in part "firm" and in part "soft", and histological section reveals them to be in part pericanalicular and in part intracanalicular.

Pericanalicular fibroadenomas

Clinical features

These tumours commonly arise in breasts of girls from puberty to the age of 25 years. Before puberty they are excessively uncommon; after the age of 25 years they become progressively more rare, and when they do occur at this late age they are generally associated with an area of fibroadenosis which surrounds them.

The lump when first observed is often $\frac{1}{2}$–1 inch in diameter, spheroidal or ovoid in shape, of firm consistency and with a smooth, well-defined surface. Characteristically, it is free from attachment, not only to the skin and deep structures, to which there is no vestige of attachment, but also to a surprising extent to the surrounding breast tissue, so that it appears to slip around like a piece of ice in a tumbler. The regional lymph nodes are not enlarged, nor is the lump painful or tender. Should pain or tenderness be complained of, the patient is usually older, and the lump is associated with some surrounding fibroadenosis which is responsible for these symptoms.

The natural anxiety of the patient invariably and properly stimulates the surgeon to remove these lumps, so that their natural history is to some extent a matter of conjecture. However, a few obdurate and prejudiced patients have clung to their lumps over a period of years, and upon this scanty material our knowledge of the natural history of this disorder is based. So far as can be judged the majority of these tumours grow steadily until they reach the size of a golf ball or, more rarely, of a cricket ball, when they cease to enlarge. Why this should be so we do not know. All that we can say is that their inception is probably mediated by an endocrine influence, and that this influence eventually ceases to operate. There are some who believe that a few of these pericanalicular fibroadenomas may change their characteristics, and transform themselves into intracanalicular tumours. The evidence for this, however, is not such as must necessarily command assent. It is based upon the facts, first, that we are uncertain as to what does become of these tumours if they are left alone, secondly that intracanalicular tumours arise at a later age than do the pericanalicular fibroadenomas, and finally that, as we have seen, section of some of these lumps shows a mixture of two types. Very exceptionally a pericanalicular fibroadenoma may undergo sarcomatous change, but such a change is even more rare than a similar process complicating the intracanalicular growth.

Pathology

The cut surface of these lumps when examined by the naked eye reveals a sandy grey surface with whorls of fibrous tissue, there may be small cysts the size of a pin's head, and the whole appears to be encapsulated within a well-defined fibrous tissue covering.

Histologically the picture is characteristic (Fig. 25). There is a considerable proliferation of the periductal fibrous tissue which everywhere consists of actively proliferating fibroblasts, the plump spindle-shaped cytoplasm with deeply staining nuclei of these cells predominating over the etiolated cytoplasm and more pale staining nuclei of the fibrocytes. The sub-epithelial fibrous tissue is, on the other hand, in this type of fibroadenoma but little affected. The epithelial-lined spaces, derived from the ducts, show usually little if any epithelial proliferation, but these

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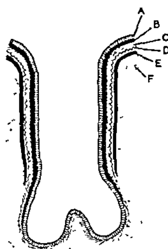


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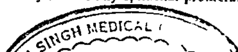
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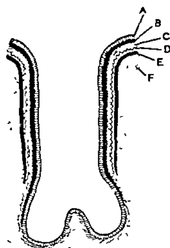


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spaces may be dilated even to the extent that they can be dignified by the name of cysts. Rarely, epithelial proliferation may occur of a type presently to be described under the heading of fibroadenosis, in which the process is more common, and even apocrine cells may be observed so that the picture may closely resemble that of fibroadenosis. There is *nevertheless an invariable distinction*, attention to which was drawn originally by Bellingham Smith, namely that in fibroadenoma there are no fat cells, in fibroadenosis these are *invariably present*.

The significance of this finding is not hard to seek. Fibroadenoma is a disease beginning in one type of structure, namely a duct with its fibrous tissue covering.



FIG. 25.—Pericanalicular fibroadenoma (× 120).

Spreading concentrically from the germ, it pushes away the surrounding breast tissue without embracing it. The lesion thus excludes the substantia propria of the breast, and contains neither fat nor nerve tissue; it is consequently painless. *It is far* otherwise with fibroadenosis which, as we shall see, is an inclusive disease. While this process is proceeding from one germ centre, adjacent foci may be active, and it is not uncommon for a clump of fibroadenomas to jostle each other in one quadrant of the breast, and give rise to a firm, lobulated mass. Sometimes the other foci may be at some distance from the first, in which case two or more discrete fibroadenomas will arise. Occasionally, the whole of the breast tissue seems to be subjected to this influence, and the organ enlarges as a multi-lobulated firm mass, a condition known as fibroadenomatosis.

Treatment

Although these lumps are symptomless and of all solitary lumps in the breast their true nature is the most readily discernible by clinical examination, nevertheless,

they grow and we know no way of stopping their growth; they are a source of annoyance and sometimes of anxiety, so they should be removed.

No fancy procedures such as submammary approaches or peri-areolar incisions are advocated. The simplest, soundest, and in the end the best cosmetic, result is achieved by making a radial incision directly over the lump and excising it with a little surrounding breast tissue. The removal of the immediate surrounding tissue is a simple and cheap precaution to ensure that adjacent microscopic foci are removed at the same time, and it is a safeguard against so-called recurrence. Bleeding vessels are sought and secured. Into the resulting cavity a rubber drain should be inserted, and this may be brought out, if convenient, through a stab incision at the lateral or inferior margin of the breast, or alternatively within the areolar margin where it is secured by one stitch to the skin. The breast tissue is then stitched together neatly over the drain with catgut threaded on a trocar-pointed needle. The skin is secured with interrupted sutures, and the breasts bandaged firmly with *crêpe* bandage or a many-tailed bandage. Considerable pressure may be applied through the bandage without risk of producing chest complications, and such pressure is helpful in preventing a haematoma. The drain is removed after 48 hours, and the stitches are removed on the seventh day. The patient gets up on the day following the operation, and can return home after the drain has been removed.

The chances of a recurrence are not more than one in seven, and no further complications are anticipated, nor does this disease predispose to any other disease of the breast.

Intracanalicular fibroadenomas

Clinical features

These tumours, unless they occur in conjunction with pericanalicular fibroadenomas, are uncommon before the age of 35 years. They differ from the above in that their rate of growth does not become spontaneously arrested; they get bigger and bigger until they eventually burst through the skin. In their early stages these lumps are characteristic. Of variable size, they are lobulated swellings with a well-defined edge, and, as in the pericanalicular type, they are free from attachment to the surrounding structures. The consistency of the lump is, however, altogether different and the lobulated mass is usually soft, feeling very like a lipoma and apt to be mistaken for such were it not for the fact that lipomas of the breast are pathological rarities. These tumours are painless and free from tenderness, nor is there any enlargement of the regional lymph nodes, provided they have not broken through the skin and become secondarily infected. As they grow these masses undergo secondary changes; cystic degeneration occurs here and there, and into these cysts haemorrhages may burst. Their final presentation on the surface is altogether unique and characteristic. As if aware of its expected behaviour, the tumour eschews attachment to the skin even when it is pressing up against it with an urgency which threatens at any moment to burst through, and when finally this happens the skin retracts away from the protruding mass and a probe may yet be passed deep to the skin and between it and the tumour in a manner to demonstrate this lack of attachment to the very end.

Once the mass has fungated in this way infection supervenes and secondary haemorrhage may occur. Even at this stage, the now large mass may be made to skid over the chest wall with a freedom limited only by the stretch of the skin.

In its later stages this lesion is sometimes known as Brodie's sero-cystic disease of the breast. The description is apt, but confusion arises from the use of this term in that, in Sir Benjamin's original account, the development was described in stages, and unfortunately the early stages so described are those characteristic of

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fibroadenosis (chronic mastitis), a condition which we now know does not subsequently develop into a tumour of this nature.

Intracanalicular fibroadenomas exceptionally undergo sarcomatous transformation, but this is extremely rare.

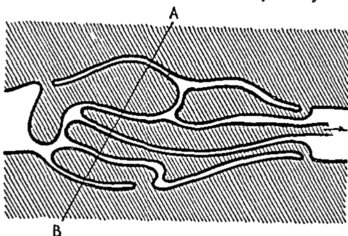


FIG. 26.—Intracanalicular fibroadenoma; a section through the line AB gives the typical histological appearance shown in Fig. 27.

Pathology

On cutting into these tumours the cut surface is grey with here and there a blue translucency, due to myxomatous degeneration. Concentric clefts divide the tumour into laminae and give to it the appearance of the cut surface of the heart of a cabbage. The whole is contained within the confines of a well-marked capsule. Later, cysts appear, and these cysts become filled with blood and lined by mucinous projections, some of which have broken away from the wall, and lie degenerating and degenerated within the lumen.

Histologically, these tumours reveal their origin from the sub-epithelial fibrous tissue. As might be anticipated from reference to the diagram (Fig. 26), hypertrophy of this layer of fibrous tissue following the line of least resistance would tend to present within the lumen of the duct, and so it is. Projections of the sub-epithelial fibrous tissue covered by normal or attenuated epithelium thrust their way into the lumen of the duct and course up or down for a variable distance. Diagrammatically the process is represented in Fig. 26. Section, for instance in the plane AB, reveals the typical histological picture (Fig. 27). We can see a collection of dilated ducts lined by somewhat flattened epithelium and crammed with finger-like projections of fibrous tissue covered by a similar layer of flattened epithelium, their sites of origin from the duct wall being above or below the plane of section. The characteristics of the fibrous tissue are clearly seen; loose and tenuous, it is liable to myxomatous degeneration which lends to these tumours their typical soft feel.



FIG. 27.—Intracanalicular fibroadenoma (× 120).

Treatment

For small tumours, local removal using the technique described above is necessary and adequate. When the tumour has attained a large size relative to the rest of the breast a simple mastectomy is generally preferable both from the point of view of ease of performance and subsequent cosmetic effect.

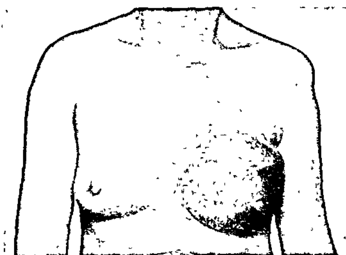


FIG 28.—A case diagnosed clinically as serocystic disease of the breast.

In large fungating tumours precaution should be taken to determine the diagnosis beforehand. It is occasionally very easy to be mistaken in the diagnosis of these large tumours, and very rapidly growing, fungating carcinoma may be strikingly free from attachment to adjacent structures, and there may be no determinable enlargement of the regional lymph nodes. Fig. 28 shows just such a case, where the physical signs mimicked precisely those of a cystic intracanalicular fibroadenoma, but which on removal proved to be a carcinoma of an encephaloid type (Fig. 29). The fact that this patient is still alive and well four years after what must be deemed most inadequate surgery confirms the growing impression amongst clinicians that many of these encephaloid tumours are of surprisingly low malignancy. Nevertheless, a blunder of this nature is best avoided, and the only sure safeguard is to remove a piece of the tumour for histological examination. When expert performance of frozen section is available this is the most desirable manner of confirming the diagnosis, in that delay is reckoned in minutes, and definitive treatment may be undertaken forthwith, a procedure gratifying to the patient, surgeon and pathologist. If, however, this highly specialized technique is not available, a delay of 48 hours, by which time a report on a paraffin-embedded section should be to hand, is not objectionable. If the section turns out to be a cystic intracanalicular fibroadenoma no danger has been incurred, and if it turns



FIG. 29.—Section of the case depicted in Fig 28, showing encephaloid carcinoma.

out to be a *carcinoma*, the short delay between biopsy and definitive treatment is, in the case of a fungating growth where little disturbance is caused by biopsy, well worth the certain knowledge acquired.

FIBROADENOSIS (CHRONIC MASTITIS)

This disease may give rise to a lump in the breast, and when it does so the lump, as we have seen, implies that one part of the breast is affected without any abnormality being detected elsewhere; that one part of the breast is affected well in advance of the rest, or that cystic degeneration has occurred in a part of the breast affected with the disorder.

Fibroadenosis may be defined as a painful or nodular condition of the breast not due to new growth, bacteriological inflammation or fat necrosis. If we take this very broad definition we find that the disease is excessively common. We find, moreover, that it is extremely difficult to determine in many cases whether the patient is worrying unduly about what must be regarded as a physiological change, or whether these changes are such as to be stigmatized as disease. After all, a large proportion of women complain of pain in the breast at some time or another, particularly 7–10 days before the menstrual period, and most breasts are somewhat more nodular than the surrounding subcutaneous fatty tissue.

It must be conceded that clinically speaking this is a disease without a "beginning point".

In 1936 in the mastitis clinic [1] at Guy's Hospital, 7 cases were given code numbers and mixed with 7 cases of similar age, taken at random, from the medical wards. Mr. E. C. Hughes, the senior surgeon at the hospital at the time, was asked to arrange these patients in order so far as severity of nodularity was concerned. This is the order in which the patients were finally arranged ("M" indicates a patient from the mastitis clinic, and "C" a control):

M, C, M, M, C, C, C, C, M, M, M, C, M, C

In this series patients with definite lumps were excluded, and such patients, of course, comprise a fair proportion of those suffering from fibroadenosis.

As for the rest, most of them have breasts more nodular than the majority of patients not complaining of fibroadenosis, so that when the condition is well developed there is no difficulty in recognizing it as a disease. It is in the early stages that difficulty arises, and this difficulty is aggravated by the natural anxiety of women who complain *of any trouble in the breast that this trouble may be or may lead to cancer.*

We are not here concerned with those cases showing a diffuse nodularity, but rather with those displaying a lump. Pathologically there is no difference, the distinction being simply one of topography. The pathological changes responsible both for a diffuse nodularity and a localized lump are as follows.

Epithelial changes

We have seen above that the normal—although the normal in regard to the histology of the breast is something which is very hard to define—is that the ducts and ductules are lined by one or at the most two layers of columnar or cuboidal epithelium. These ducts are distributed throughout the breast tissue, and are everywhere separated by an intervening stroma, consisting of fat and fibrous tissue. The epithelial changes which occur in the disease of fibroadenosis can be divided into two main types.

Adenosis

When we look at the section of the breast of a patient who has never complained of symptoms relating to the breast, and in whom on palpation the nodularity is not

[1] All expenses incurred at the mastitis clinic are defrayed by a grant from the British Empire Cancer Campaign.

excessive, a patient in fact whom we may regard as "normal", we find an appearance which is reproduced in Fig. 30. Throughout any one field of a magnification of 120 we will see one or two ducts with their terminal ductules, and the mass of the field will be occupied by stromal tissue. The phenomenon of adenosis, well described by Dawson (1933), consists in a multiplication of the ductular or alveolar systems, such that on examination of a field at this magnification the appearance is as in Fig. 31. Here the intervening stroma has been reduced to a minimum, and the whole field is peppered with alveolar systems to the exclusion of all else. The glandular system of the breast has multiplied to a vast extent without any characteristic changes having taken place in the minute structure of each alveolus.

We have seen how clinically fibroadenosis is a disease without a beginning point. In the case of adenosis this is the same. Who is to tell what the normal number of alveoli is, or when this is becoming pathologically excessive? Figs. 30 and 31 represent extremes about which there can be doubt, but somewhere along the line between the one and the other we may view sections in which it is impossible to tell whether the number of alveoli seen on section is excessive to the extent of being pathological.

Epitheliosis

The second change which affects the epithelial tissues of the breast is well termed by Dawson "epitheliosis". This change concerns not the number of ducts or alveoli but the changes in their minute structure. It is customary to describe these changes in a series, each step in the series appearing, from the manner in which they are described, to lead logically and often inevitably on to the next. Such a sequence, however, may be and probably is fictitious. If we adhere to this conventional sequence for descriptive purposes it must be constantly borne in mind that the later stages in the series may quite readily develop from a normal breast without the intervention of any of the preceding stages. On the whole the evidence which we have tends to show that this is usually the case, and constant preoccupation with this likely behaviour is necessary if we are not to be misled in regard to the possible pre-malignant nature of the disease fibroadenosis.

(1) The epithelium lining the ducts and terminal ductules multiplies in thickness so that the lining consists of three or more layers of epithelial cells laid directly the one on the other, like bricks in a wall, and without the intrusion of any separating fibrous tissue or vascular stroma (Fig. 32). The effect of the absence of such stroma would seem to be that the layer of cells nearest to the lumen of the duct, and the one therefore the farthest away from its source of nutriment, tends to degenerate, particularly at the luminal border, which becomes feathery. This degenerative tendency spreads throughout the cell, which disintegrates, and the products of this disintegration are cast off into the lumen, usually as amorphous debris (Fig. 33). Occasionally this debris consists of cellular elements, presumably derived from the epithelial lining of the ducts, and these elements have a foamy cytoplasm rich in cholesterol, and are not infrequently referred to as colostrum corpuscles (Fig. 34). *Pari passu* with these changes the ducts dilate Much argument is ranged round the cause of this dilatation, but the view that they dilate in order to accommodate the excessive products of degeneration is one which has much to recommend it.

(2) Here and there throughout a section large pale cells may be seen lining somewhat dilated ducts. These large pale cells, unless they be thrown into papillomas, are usually only one layer thick, and a characteristic feature of the cells is the relatively large proportion of brightly staining eosinophil cytoplasm. Their origin has been much debated; that these cells secrete in an apocrine fashion, namely by extrusion of a part of their cytoplasm into the lumen, is readily appreciated by reference to Fig. 35, in which some of these cells can be seen in the process of active secretion; lobules of cytoplasm are in the process of being cast off into the lumen of the duct,

some of these globules being still attached to the parent cell by a waist, others being entirely free. Their morphological appearance and their mode of secretion is suggestive that they might be of sweat-gland origin and constitute the remnants of sweat glands included during the course of development of the breast; such a view, however, is hard to maintain. In the first place they are observable only in connexion with other changes which have been judged pathological, most commonly in fibroadenosis, rarely in fibroadenoma (Fig. 36). Furthermore, it is not uncommon to be able to trace in the wall of a duct a gradual transition from epithelium of normal morphological characteristics giving place gradually to cells of a frankly apocrine type (Fig. 37), and it must be concluded from such that these cells are derived from the normal epithelium of the duct as a result of some influence, of the nature of which we are as yet in complete ignorance. Whatever may be the source of these characteristic cells, investigators are unanimous in their views that they have no particular sinister or pre-cancerous tendencies.

Sometimes apocrine papillomas may be observed (Fig. 38). These papillomas are in their formation as characteristic as the cells themselves. Their shape is umbelliferous, like an elm tree on the sky-line. Their stroma is scanty, and their attachment to the duct wall is consequently by a slender trunk which is readily fractured, so that they tend to be discarded into the lumen of the duct.

(3) To return to the proliferative changes of the columnar or cuboidal cells first described, we find in advanced stages of this disease that such cells become projected into the lumen of the duct as finger-like papillomatous protrusions (Fig. 39). There is a wealth of difference between such papillomas and those characteristic of the apocrine cells. In formation they present a strong, wide base of attachment to the duct wall, and this base carries an abundant fibrous tissue stroma and many blood vessels; their nourishment is consequently secure, and their rupture and discarding into the lumen of the duct a rare event. The histological appearance of these projections suggests vigorous growth, and we are not surprised that in their later stages they may proliferate, and come to occupy progressively more of the vacant lots available within the duct. In Fig. 40 we see what appears to be a fusion of these papillomas at their tips. In Fig. 41 they have all tended to grow towards the centre of the duct, where their apparent fusion gives rise to a cart-wheel appearance. In Fig. 42 this process has become so elaborated that the spaces in the duct are reduced to veritable chinks. Finally, in Fig. 43 the whole of the lumen has been replaced by epithelial cells closely packed within the duct. It is at this stage that the greatest difficulty arises in differentiation [illegible] is unequivocally to be dia[illegible] can be observed at any pl[illegible] erved within the lymphatics or blood vessels. In the majority of cases, however, even in frankly malig- [illegible] of evidence in the minute [illegible] fortune, and other criteria [illegible] attempt by the epithelial cells to range themselves in an alveolar pattern, that there is total absence of polarity of these cells, or that other suggestive morphological changes have taken place. It cannot be wondered at that the opinion of different histologists may vary in regard to any particular section at this stage, and that the less experienced in such doubtful instances advise radical mastectomy.

Cysts

[illegible] into the [illegible] n is [illegible] this process these spaces become completely walled off, and constitute [illegible]



FIG. 30.—Section of breast which might be regarded as normal (× 120)



FIG. 31.—Adenosis (× 120)

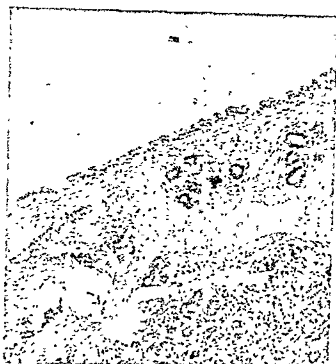


FIG. 36.—Apocrine cells occurring in a fibroadenoma (× 120).



FIG. 37.—Transition between pavement epithelium and apocrine cells (× 120).



FIG. 40.—"Arcade" or "viaduct" formation (× 120)



FIG. 41.—"Cart-wheel" appearance (× 120).



FIG. 42.—The lumen of the cyst is reduced to a few chinks (× 120).



FIG 43.—The duct is crammed with epithelial cells (× 120).



FIG. 40.—"Arcade" or "viaduct" formation (× 120).



FIG. 41.—"Cart-wheel" appearance (× 120).

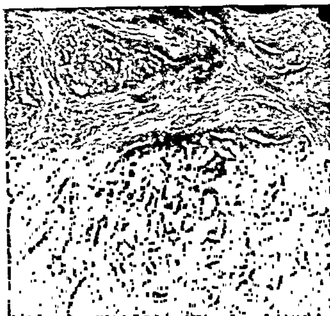


FIG 42 —The lumen of the cyst is reduced to a few chinks (× 120).



FIG. 43 —The duct is crammed with epithelial cells (× 120).

It is difficult to be certain in studying these sections whether we are lookir dilated duct or whether the space observed is circumscribed, without inlet or and can be characterized as a cyst. To make this distinction it might be helj follow what is probably the course of development of such cysts.

It may be assumed that desquamative products in a duct cause the duct to in order to accommodate the accumulation of material both cellular and non-ce Much of this material is engulfed by phagocytes migrating into the lumen frc surrounding stroma, so that eventually the space may become filled with clear The debris, together with the phagocytes, accumulates at the orifices, both a and efferent, of the dilated segment, and sooner or later blocks the entranc exit. When this happens there is not at once a cessation of these processes c integration, so that more and more material is thrown out into what is now a



FIG. 44—A cyst lined with flattened epithelium (× 120).

its walls becomes flattened and pavement in type (Fig. 44). If such a ... correct we may regard those spaces, lined by abundant cuboidal epithelium, as b ducts still in continuity with the adjacent ductular system, or at least duct which this continuity has but recently been cut off (Fig. 45). In the spaces line flattened epithelium the raised intraluminal tension is betrayed by their circular sl and these we may regard as true cysts. Once a cyst is formed in this way, howe secondary epithelial proliferation may occur in the wall, and this proliferation i be either of the apocrine or columnar-cell type, so that apocrine papillomas, or c true papillomas, may make their appearance (Fig. 46).

So far we have regarded the changes which go to make a cyst as if they constitu a one-way traffic, but it may be assumed that not only is there accumulation of mate within the cyst but absorption of the contents too, so that the intraluminal tens varies according to which of these two processes predominates. It is possible t secondary epithelial proliferation is promoted in those cysts in which the hydrost



Fig. 45.—Dilated ducts (× 120)

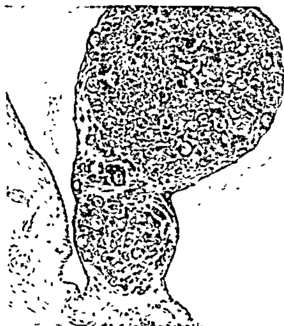


Fig. 46.—A papilloma growing into a cyst (× 120).

tension is reduced by the process of absorption overcoming that of accumula
Certainly at operation, when these cysts are punctured and the intraluminal tensi
such that they burst almost with the force of an explosion, the lining is invari
made up of flattened, pavement epithelium. In the vast majority of cases the for
tion of a cyst of this description represents an end process. The contents of such a
may seem to disappear; it is possible, too, that their epithelial lining may be repl
by fibrous tissue, so that they disappear histologically speaking as well; or the bal
between absorption and accumulation may be so nicely adjusted during the co
of years that these cysts linger on, with little variation in size or tension, into extr
old age.

Such, however, is not unfortunately their inevitable behaviour. In some cases
we have seen, papillomas may develop, and in others carcinomas may appear in
wall. The proportion of cysts which behave in this malignant way is quite imposs
to assess, but we can judge that such a development is very rare.

The processes which we have discussed occur generally at the periphery of the br
tissue, and at this site the length and tortuosity of the duct between the area affec
and the orifices at the nipple are such that occlusion by impacted debris is bound
occur somewhere along its length. If, on the other hand, these processes oc
adjacent to the nipple, where only a short segment of duct lies between them and
exterior, occlusion is less certain, and instead of cyst formation a discharge from
nipple may occur.

It is not the purpose of this article to discuss the very difficult problem of
significance of nipple discharges, nevertheless it would not be out of place to rec
that epithelial proliferation associated with nipple discharge is, on the whole and
the minds of most clinicians, of somewhat more sinister significance than the epithel
changes associated with cyst formation at the periphery. Can it be that the differen
if such there be, lies in the different hydrostatic tensions involved in the two types
condition? In the first, when cyst formation predominates, the hydrostatic tension
extreme, and the epithelium appears to be compressed and inert. When dischar
from the nipple occur this tension is less, the efferent segment acting as a safety val
and proliferative epithelial changes take place with greater facility.

Mesodermal changes

o [illegible] fibroadenosis, [illegible]
[illegible] hroughout a great
[illegible] e substantia propr
[illegible]
of the breast, namely fat, supporting stroma, blood vessels and nerves. If we ta
sections from a breast suffering from fibroadenosis at an early and perhaps somewh
painful stage, the most striking feature of the microscopic picture is the very gre
fibroblastic activity which is taking place (Fig. 47). Everywhere we see active fibro
blasts with their relatively plump, spindle-shaped cytoplasm and deeply stainin
nuclei. The random sample taken from the same breast some years later, when th
symptoms are less in evidence and when the fires of the disease have been dampe
down, shows a somewhat different picture (Fig. 48). Here, too, there is some fibro
blastic activity, but many fibroblasts have matured, and in their place we find th
more etiolated structure of the fibrocyte and a high proportion of inactive collage
fibrils.

After the menopause the histological picture is characteristic. Very little fibrou
tissue reaction is proceeding, and the field is almost wholly occupied by inert collage
fibrils (Fig. 49).

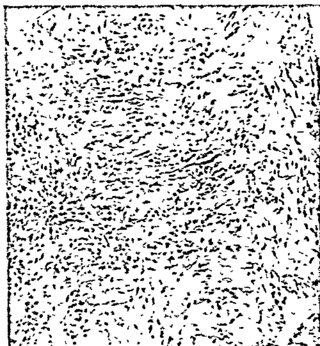


Fig 47.—Intense fibroblastic reaction (× 120).



Fig. 48.—Moderate fibroblastic reaction (× 120).

Such then is the life-history of the fibrous tissue *in this disease*. *Why* this proliferation occurs is not known. In some ways it reminds us of granulation tissue, and it is conceivable that it *may exert a controlling influence on the epithelial* changes which are primarily induced. At least we can say that *when, as in the* fibroadenosis artificially produced in the experimental animal by the injection of oestrogen, such epithelial changes are notorious for their *progression to cancer*, this fibrous tissue proliferation is conspicuous by its absence (Fig. 50).

Accompanying the fibrous tissue proliferation, other mesodermal elements can be discerned in excess. The principal among these is the small round-cell infiltration which occurs in the periductal fibrous tissue *in relation to actively proliferating* epithelium. A not altogether fanciful flight of the imagination might assign *also to these lymphocytes some controlling* or protective influence over epithelial encroachment. At least, as we shall see, something must account for the striking infrequency with which fibroadenosis produces a cancer, having regard to the sinister appearance of the epithelial changes characteristic of this disease.

Lastly, sections of fibroadenosis invariably show included fat; it is this feature which in the last analysis is the absolute arbiter of histological differentiation from fibroadenoma.

All the preceding changes which we have described *can occur in fibroadenoma*, although it is rare for the epithelium to proceed to such florid expressions as is com*mon in fibroadenosis. This universal appearance of fat is simply indicative of* the diffuse nature of this latter, as opposed to the localized nature of a fibroadenoma. It seems that the changes of fibroadenosis are ill confined, and involve the breast tissue in an insidious and indiscriminate manner. The presence of fat cells is indicative of the presence, too, of other tissues proper to the breast substance, namely nerves, and if we can imagine the fibrosis in fibroadenosis ramifying round the nerve endings, from which it is rigidly excluded in fibroadenoma, we see at once why the former tends to be a painful disease, and the latter, if unassociated with surrounding fibroadenosis, painless.

Such then are the histological characteristics of fibroadenosis. But are they exclusive to this disease? Figs. 51–53 illustrate sections taken at the post-mortem table from the breasts of women who have *died from some cause unconnected with the breast* and in whom no complaint of breast disorder was ever known to have been made. It will be seen that the histological changes there depicted are *precisely those that we have* just been describing. It is true that in a hundred such post-mortem specimens these changes are found with much less frequency than in a hundred random samples taken from the mastitis clinic, but that they are found so commonly is a further warning that, histologically as clinically, the end-points of this disease are impossible to define.

Clinical features

Fibroadenosis, both in its localized and diffuse forms, occurs at all ages and in *both sexes*, but the vast majority of cases are met with in women between the ages of 30 and 50 years. Fig. 54 shows the age incidence of the onset of symptoms in a series *of* 317 cases. Apart from this very large group there is a tendency for a lump of fibroadenosis to appear in the newborn and at puberty in both sexes. About the time of the climacteric and *sometimes earlier*, a discoid or granular *plaque* may appear in the male. These specialized forms of fibroadenosis can be quickly dismissed. There can be little doubt that in the newborn *they are due to an endocrine influence*, perhaps the effect of the maternal endocrines operating through the placenta, and at puberty and at the time of the male climacteric *they are caused by the upset in the endocrine* balance at these times. In each case the microscopical change is obviously benign and because of this no sinister significance can be *attached to their appearance, nor*



FIG. 49.—Inert collagen fibrils (× 120).



FIG. 50.—The so-called fibroadenosis induced by treating a mouse with oestrogens (× 120).



FIG. 51.—Specimen taken from the post-mortem room (× 120)



FIG. 52.—Specimen taken from the post-mortem room (× 120).



Fig. 53.—Specimen taken from the post-mortem room (× 120).

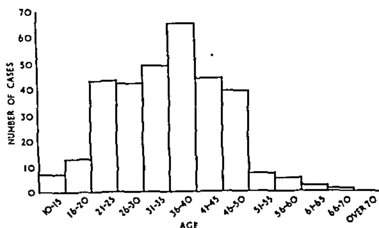


Fig 54.—Diagram showing age of onset of fibroadenosis in 317 cases.

does the exhibition of this phenomenon in early life mean that the more common diffuse fibroadenosis is likely to appear later. No case can be found in the literature of [illegible] They are tender, firm, [illegible] often subareolar in distribution. There is never any attachment to the deep structures, though occasionally some slight attachment to the nipple may be demonstrated. They differ from the common form of fibroadenosis in that they have a tendency to greater tenderness, and in fact in this disease in the newborn, bacterial inflammation may supervene and an abscess form. Usually in the infantile form the lesion disappears in the course of a few

weeks or months. At puberty the natural history is somewhat longer, but in the case of girls, in whom this disease is more common, the physical signs become slowly absorbed by the general development of the breast, so that after a year or eighteen months no abnormality can be detected in the breast previously affected.

The treatment of these lumps, apart from the supervention of bacterial infection, is reassurance, with the certainty that they will ultimately disappear. In the case of fibroadenosis in the male it may be true to say that their disappearance is accelerated by the prescription of androgens, but it is too early yet to be sure whether this hormone has a beneficial effect, and in the absence of more specific proof it is wiser to allow them to disappear of their own accord. More exceptionally in this type the tender plaque will persist for so long that operative removal of the diseased area is called for to relieve the symptoms.

We come now to the common type of fibroadenosis, and this can present in various ways. In order that the description of the physical signs should be quite clear it will be necessary first of all to define certain terms which are used in this connexion.

Granularity implies an irregular feel of the tissues, in those cases in which the nodes of irregularity are 1–2 millimetres in diameter, or in plain language, in which the mass appears to be studded by little granules the size of pins' heads.

Granularity is a physical sign given by breasts which are the site of adenosis, each little granule consisting of a clump of alveoli. Occasionally minute cysts will give this feel, but by the time the cyst becomes appreciable and has reached a situation beneath the skin where it can be felt, it is usually larger than a pin's head, and the term no longer becomes applicable.

Nodularity is the term applied to that irregularity which is most commonly encountered in this disease. It is an irregularity in which the nodules are ½–1 centimetre in diameter, usually irregular in shape, and connected by strings or threads of firm-feeling tissue. This feel is given by small cysts surrounded by areas of fibroadenosis or by nodes of fibrous tissue lying in the breast, traversed by intersecting bundles of fibrous tissue, like a three-dimensional lattice-work.

Lobularity is applied to the irregularity consisting of discrete nodules of more than 1–1½ centimetres in diameter. The commonest histological picture giving rise to such a feel is that in which fat lobules are projecting from the constraining influence of excessive fibrosis regularly disposed. Occasionally cysts will give rise to lobularity, but it is unusual for cysts of this size to be uniform in their dimensions and so evenly dispersed as to give this impression. Rarely fibroadenomatosis, a condition in which much of the breast tissue is replaced by multiple and closely aggregated fibroadenomas, will give rise to a feeling of lobularity, like a bunch of cherries in a bag.

In fibroadenosis, granularity, nodularity or lobularity affects a part of one breast, the whole of one breast, a part of both breasts or the whole of both breasts, so that the physical signs are of great variability. In this article we are concerned not so much with the diffuse forms of this disease as when the process is sufficiently aggregated in one part of the breast tissue to constitute a definite lump. When this is so the lump is due to a variety of histological pictures.

In the first place and most commonly it is due to a cyst. This cyst may lie naked within relatively normal breast tissue, or clothed in a mantle of fibroadenosis. In the former case, and despite the deceptive surroundings of soft tissue, it is usually possible clinically to identify its true nature. The lump will be of variable size, the surface will be smooth, the edge regular and the consistency variable, depending upon the degree of tension within the cyst. Nevertheless with practice and concentration it is nearly always possible to elicit fluctuation in such a lump. It can be differentiated from the elastic feel of a soft fibroadenoma by the lobular nature of the surface of the latter.

As we shall see when we discuss the treatment of these lumps, the confirmation of

their nature by means of aspiration is only very exceptionally warrantable. Suffice it to say here that aspiration is an uncertain method of treatment and a misleading method of diagnosis

If the cyst is surrounded by an area of fibroadenosis, as is somewhat more common, the physical signs are more difficult to establish. Clothed and protected by this firm casing, it may be impossible to elicit fluctuation, and the existence of a cyst may be surmised only by the fact that whereas all the other physical signs indicate an innocent lesion the bulk of the mass suggests that some space-occupying process exists in the centre.

Next the lump may be due to a local area of breast in which the processes of fibroadenosis are far in advance of those in adjacent parts of the breast tissue. This area may or may not include one or more cysts, the existence of which can be, as we have seen above, only a matter of surmise. The physical characteristics of these lumps are well known. They occupy any part of the breast tissue, but are commonest in the upper and outer quadrant, and are only exceptionally met with in the central and subareolar parts of the breast. They may be somewhat sector-shaped, indicating that they have arisen in the ramifying branches of one particular duct, but this feature is more unusual than one would suppose from reading the common descriptions, and such is not to be wondered at when we realize that the branches of any particular duct encroach, with a fine disregard for their alleged segmental distribution, on the property of their adjacent fellows. Just as in shape, so in size these lumps vary within wide limits. The edge is irregular and the consistency firm. The surface is granular or nodular, or more rarely lobular. There is only in exceptional cases any attachment to the nipple, and attachment to the skin should always suggest carcinoma rather than fibroadenosis. Attachment to the deep structures never occurs. The lump may be slightly tender to the touch, and there may be some enlargement of the regional lymph nodes, but these nodes are soft and their size varies. Commonly, both the size and tenderness of a lump of fibroadenosis increases 7–10 days before a menstrual period, and there is a regression of both these features on the first or second day of the period.

Natural history

The initial sympton of fibroadenitis is usually pain or the discovery of a tender area while washing The symptom of pain often prompts the patient to examine the breasts for a cause and, as a result of this, an area of thickening which may or may not be pathological is discovered. This discovery often and naturally throws the patient into an agony of apprehension, and she will run to her doctor complaining openly of the symptoms, but secretly and principally of fear of cancer.

As mentioned above, the pain and to a less extent the nodularity are usually affected by the menstrual period. In addition to this monthly periodicity there are usually long-term intervals of exacerbation and remission For six months or so the patient will be acutely conscious of her disease, and following this there will be a similar interval in which symptoms are minimal or absent. The whole disorder tends to be self-limiting, and runs a course usually of 12–15 years. Commonly at about the time of the menopause first the symptoms and, after some delay, the signs disappear.

If this disease has produced one or more large cysts, these may persist for an indefinite period, but on the whole they become lax, collapse and eventually disappear. Should the pain continue beyond the climacteric it is very unlikely that it is due to disease of the breast, and far more likely that it persists as a neurosis.

Pregnancy and lactation exert a profound effect on this disease. First, the syndrome is rare in women who have had many children. Fig. 55 shows the fecundity rate in patients attending the mastitis clinic and although, without a comparable table

showing the fecundity rate of the population at large, this diagram cannot give accurate values in regard to this problem, it will *nevertheless* be seen at once that the disease is comparatively rare in women who have had more than two children. This feature of the disease is further exemplified by its comparative rarity in communities in which large families are common; in backward agricultural districts and amongst primitive people everywhere its existence is minimal or absent.

It is not certain whether this protective effect is a result of pregnancy or of the subsequent lactation; *probably the natural development of the breast during both* these physiological processes contributes to its general well-being, and pregnancy, with or without lactation, supervening on a case of established fibroadenosis is always

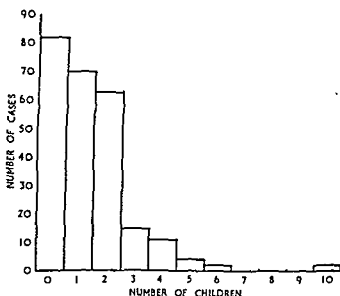


FIG. 55.—Fecundity rate in 249 married patients attending the mastitis clinic.

beneficial to a greater or less degree. To say that pregnancy cures fibroadenosis (as is sometimes taught) would, however, put this too strongly. Very occasionally pregnancy may have a scarcely discernible effect on the course of the disease. Occasionally, too, pregnancy may abolish it. More commonly the effect is a variable one. At about the fourth or fifth month of pregnancy the symptoms disappear and the nodularity is lost within the general glandular development of the organ. After *parturition and during the period of lactation the breasts function normally and give* rise to no trouble. It is interesting that this disease would appear to interfere in no way with the function of the breasts when the demands of lactation are made. Patients with fibroadenosis are able to suckle their children with normal facility. The subsequent history of these patients depends upon whether further pregnancies follow. If this is so the disease seems to be held permanently in abeyance; if no subsequent pregnancies ensue the period of relief varies from nine months up to an indefinite time. Generally with the return of the menstrual period some symptoms recur, and often by the time the baby is 18 months old the patient's condition is as before.

The medical attendant is not infrequently asked by these patients whether they *should have children. There is no doubt that the answer is unequivocally "yes"*, and one might even add that the more children they have the better for their disease. Furthermore, lactation will be normal and beneficial.

Pre-cancerous tendencies of fibroadenosis

For a hundred years or more there has been a suspicion that fibroadenosis, or, as it has been called for most of that time, chronic mastitis, may be a pre-cancerous lesion. With all the work that has been done on this matter, and despite all the energies which have been directed towards its solution, we are still unable to answer this question. The evidence in favour of such a hypothesis is presumptive.

Histologically the epithelial changes characteristic of fibroadenosis described above seem to lead gently, stage by stage, from the normal structure through all the phases of fibroadenosis to culminate in cancer. Such evidence is, however, open to grave objections. This gentle gradation (as it has been termed) is of course revealed only when a number of sections are taken from different patients and, as it were, shuffled and sorted in an order convenient to demonstrate this point. It is impossible to show the transition from one stage to another in any one particular case, and it is an assumption which is probably incorrect that such a series of steps is the common mode of cancer production in the human breast. Certainly the final stages can appear unheralded by any of the preceding ones, and cancer can indeed graft itself on to any of the histological pictures represented in such a series.

At first sight the most suggestive piece of evidence comes from the experimental laboratory and from the mouse. If oestrogens are injected into mice, or administered in some other way, for instance by inunction, it is possible to produce cancer of the breast with great regularity and in a high proportion of the strains. This proportion depends to some extent upon the genetic constitution of the mouse, and also upon the presence or absence of the milk factor, but in the main the effects of oestrogens are so potent in this regard that, provided sufficient is given, constitutional and other barriers are overwhelmed.

If oestrogens are given in smaller doses changes are wrought in the breasts of mice similar in some respects to fibroadenosis in man. Furthermore, if carcinogenetic doses are administered, the intermediate stages of the breast changes are likewise similar to human fibroadenosis. These findings together exert an irresistible fascination on the minds of many histologists and experimentalists who aver on such grounds that fibroadenosis must be pre-cancerous. Nevertheless, these findings from the experimental animal are by no means conclusive. Apart from the fact that it is notoriously dangerous to draw conclusions as to human behaviour from animal experiments, there is the very important consideration that the intermediate condition—the half-way house, as it were, on the way to cancer—which oestrogens produce in mice is in fact very different from that found in fibroadenosis in man. Cystic and epithelial changes are there, but the most striking and almost invariable difference is the absence of fibrous tissue. This difference is so considerable that, however we may regard the function of the fibrous tissue in fibroadenosis in man, it is certainly risky to base firm conclusions upon a comparison of histological behaviour so dissimilar (Fig. 51).

The only way in which we can be certain as to whether a disease A predisposes to a disease B is to take a sufficient number of cases of disease A, follow them up for a sufficient length of time, and see whether disease B appears in this series in a significantly greater proportion of cases than in the population at large. It may be thought that this experiment has been performed almost *ad nauseam* in the case of human fibroadenosis, but is this indeed so? A series which excited a great deal of interest and which is still perhaps the best known is that of Bloodgood (1932). His general conclusions were that fibroadenosis, or "cystic mastitis" as he called it, was not a condition which predisposed to cancer. Later, however, an even more comprehensive series was examined by Warren (1940), whose general conclusions were that cancer of the breast is 4·5 times as common in patients with fibroadenosis as in the rest

of the population. It may first be wondered at that two such careful investigators should come to what appear to be diametrically opposite conclusions. This, however, is not strange; what is surprising is that two such investigators should come to any conclusion at all.

We have seen that both histologically and clinically fibroadenosis is a disease without a beginning point. If Warren states that cancer is 4·5 times as common in patients with fibroadenosis as in the normal population, we must at once inquire whom he regards as normal and whom he regards as patients with fibroadenosis. This problem may be summed up by saying that fibroadenosis is a disease so vague, and its manifestations in minor degrees so common throughout the human race, that it cannot be defined with a degree of precision sufficient to allow accurate statistical conclusions to be drawn.

What is far more important, however, is how we should deal with this condition in practice. This article is concerned with lumps in the breast, and fortunately when the disease is aggravated to form a lump the problem is quite clear cut. Nevertheless, we may state that when the process is sufficiently diffuse to give rise to generalized lumpiness, and when the diagnosis is absolutely certain on clinical grounds, both on account of its very diffuseness and on account of a number of symptomatological arrows all pointing in the same direction, then there is no need to take active steps to prevent the onset of cancer other than periodic examination.

Treatment

When fibroadenosis is aggregated into a lump, the diagnosis of that lump must be uncertain. The treatment is therefore to remove the lump and make certain.

Aspiration

Before elaborating this proposition, a word must be said about aspiration. Aspiration is used for diagnosis and for therapy, and in neither instance is it satisfactory. As far as diagnosis is concerned, the needle may fail to find or penetrate the area in question, and no clear fluid be withdrawn where clear fluid exists, or conversely clear fluid may be withdrawn from a cyst adjacent to an early carcinoma. Further, although carcinoma arising in the wall of a cyst is a rare occurrence when considering all types of breast lesion, it is not so excessively rare when we consider solitary lumps of doubtful nature clinically—just those lumps in fact for which the diagnostic acumen of the exploring needle is most required. The recovery of clear fluid from the aspirating needle in these lesions is diagnostically misleading.

With regard to treatment, aspiration must be considered equally unsatisfactory. The removal of the contents of a cyst will give gratifying results only when in any case the cyst was in the state in which absorption was taking precedence over accumulation, and one therefore in which spontaneous disappearance was likely in the course of time. Furthermore, it has no effect at all on adjacent, smaller and unpenetrated cysts, which are left to grow and to cause annoyance and anxiety subsequently.

This is not to say that in the majority of cases aspiration will not yield the correct diagnosis, but so will a really careful clinical examination, and aspiration is not much of an improvement on this; nor is it to deny that in many cases aspiration will cure a cyst; but the difference in disturbance to the patient between aspiration and removal is so trivial and the difference in certainty of diagnosis and to a less extent in success in treatment is so great that the operation must nearly always be preferred.

Removal

The operation for removal of these lumps is precisely as described for the removal of a fibroadenoma, with the exception that a moderately generous amount of tissue

should surround the pathological lesion. Difficulty sometimes arises in this respect with the inexperienced operator. He must decide before the skin is incised exactly how much breast tissue he is intending to remove, and abide by this decision. Otherwise as he cuts farther and farther into the breast he seems to lay bare more and more pathological tissue which he is unwilling to leave behind, so that more and more of the breast is slowly and surely manoeuvred through his skin incision, and eventually by this obstetrical exercise most of the breast tissue is extracted, like the birth of some ungainly monster.

Once the lump, with some surrounding tissue, has been extracted, it is taken to a good light, while the assistant stuffs the wound with gauze and applies pressure. The lump is then cut across in many planes, fingered and closely inspected. The differentiation between an innocent and a malignant lump has been so well and so many times described that only a brief recapitulation will be necessary here.

The malignant lump cuts as if it desired to be cut, and often like a pear or a potato. The cut surface may retract; it may be yellow and gnarled or stained with altered blood. On scraping it little hair-like processes of fibrous tissue may stand up as if the surface of an unplaned piece of wood had been scraped with a knife against the grain. Sometimes the surface is white but studded here and there with yellow specks—cancer cells cramming the lumen of ducts.

The innocent lump may be a cyst, but if solid it dislikes being cut and rolls about under the blade of the knife instead of standing up to it. When cut, the surface is clear white or grey and bulges outwards. Sometimes there are small cysts containing clear fluid included in the mass; sometimes the yellow specks described above may appear, and are due to clumps of alveoli or even cells of a duct papilloma filling the lumen of small ducts. In this, and in some other cases, naked-eye diagnosis may be uncertain, but such uncertainty is at this stage and with a moderate degree of experience unusual. If the diagnosis is certain and the lump malignant, the incision is closed with a continuous suture of nylon or salmon gut tightly sewn so that no blood will escape, the instruments, towels and gloves are changed and radical mastectomy is proceeded with. If the lump is undoubtedly innocent the wound is everted as far as possible and bleeding points are sought and controlled by stitches mounted on trocar-pointed needles. A drain is inserted and the wound dealt with in the manner described above.

What should be the procedure if, after examining the lump, doubt still remains? Should the operation have taken place in an institution where technicians expert in the performance and interpretation of frozen sections are available, a certain diagnosis will be reached [illegible]
Very few institu [illegible]
least rapid para [illegible]
wise the lump sh [illegible]
3 days between the performance of a biopsy and definitive treatment for cancer has no adverse affect on the prognosis, so that the lump is dispatched forthwith to the histological laboratory with an urgent request for an early report. The wound is then sewn up and the patient and surgeon wait upon events.

In the case of the innocent lump so treated the prognosis is good. The situation is much like that of nodular goitre. In this latter disease the most diseased part of the gland is removed, leaving some behind which may be a source of subsequent trouble. Nevertheless, if the part removed and the part left behind have been well chosen, the amount of disease still available is minimal, and in any case the operator is legislating only for a limited period of time—until about the menopause, after which serious developments are unlikely. So it is with a lump of fibroadenosis. We must admit that this is a disease of the whole breast and that the chances of recurrence following local removal must exist, but the breast tissue left behind is only slightly affected

(otherwise the diagnosis would have been certain and the operation probably not have been performed); we are only legislating in the majority of cases for 5–10 years—until the menopause—so that it is unlikely that this part of the breast will have time to become a nuisance before the whole disease undergoes a natural regression. Such in fact is found to be the case. Of those women who have had a solitary lump in the breast removed, under 25 per cent, and it may be well under, ever have any further trouble. If they do, the situation is not so desperate after all. A second operation has to be performed, but they have been through it before, they are not anxious, they know that unless it is proved necessary only a trivial operation will be performed, and they infinitely prefer this to having lost the breast on the first occasion.

Hormone therapy

And now a word about hormone therapy. Fibroadenosis is probably a disease of abnormal hormone activity and it is reasonable to suppose that we might treat it by adjusting the hormone imbalance. This may be the case, but so far the correct hormone treatment has not been found. Much experimental evidence goes to show that oestrogens or oestrogen-like substances may be implicated in causing the disease. It is difficult to be certain of this because fibroadenosis is a disease of so many spontaneous variations that the effect of any substance upon it can be gauged only when enormous numbers are studied. Although it is true that the symptoms and signs of fibroadenosis may ameliorate after oestrogens have been administered, so they may if the condition is left alone, and it was our impression at the mastitis clinic (Atkins, 1940) that the series left alone did better than those given oestrogen, a confirmation of the view that, if they were effective at all, oestrogens aggravated the condition. More might theoretically be expected of androgens, in some respects the natural antagonists of oestrogens. Here again suggestive results were obtained (Atkins, 1949), and we formed the impression that while the androgens were being administered, and for a short while afterwards, the symptoms and signs were ameliorated in a significantly greater proportion in the series so treated than in the series left alone. Other hormone preparations were tried, but did not give sufficiently promising results in the preliminary investigation to suggest that it would be worth while to test them out seriously.

What then are we to say about hormones in this condition? The only hormones of demonstrable efficacy are the androgens, [illegible]
by mouth in doses of 15 milligrams a day [illegible]
fibroadenosis—the lump in fact—with wh[illegible]
of prescribing hormones. The removal of the lump is necessary for diagnosis and is of itself sufficiently effective treatment. In one of our patients for whom this treatment was carried out, but to whom in addition large doses of androgens were given subsequently, a carcinoma of the breast developed within a year at the exact site of the local operation—one of the two patients to be so affected out of over 200 studied for periods up to 14 years. The prescription of androgens cannot therefore be a sure protection against the subsequent development of cancer. In fact we do not know the precise action of this hormone on the human breast and, while this is so, its use is better avoided. The same may be said in regard to the diffuse forms of fibroadenosis. The benefits accruing are so temporary and the ultimate affect of androgens so un-[illegible] careful and watchful work [illegible]
disease itself, once the diagnosis is established, is trivial. The patient [illegible]
in the confident expectation that cancer will not supervene. She should nevertheless be asked to report at 6-monthly intervals for examination, the alleged purpose for

which is to see that no fresh manifestations of this innocent disease have appeared, but in fact to watch over the patient so that in the unlikely event of cancer appearing this may be dealt with contingently and radically.

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(*See also British Surgical Practice:* Breast—Chronic Mastitis, Vol. 2, page 487, S. Key 79.)

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BURNS—FLASH

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DEFINITIONS AND INTRODUCTION

Flash burning is a term now widely applied to define burns inflicted in a short period of time by a chemical, or atomic bomb, explosion. Chemical explosion flash burns have been seen since the first days of gunpowder and are unfortunately seen quite frequently after ammunition, petroleum and gas explosions. Interest in flash burns has quickened since they were inflicted in such devastating numbers by the atomic bomb attacks on Japan, due to the fact that, of all the acute injurious effects of nuclear-fission bombs, flash burning had by far the longest range. Consequently this article must be concerned mainly with atomic bomb flash burns.

Chemical explosion flash burns are similar to, but not identical with, atomic bomb flash burns. However, because chemical explosion flash burns are quite common, they are referred to from time to time to assist in presenting information about atomic bomb flash burning. The procedure adopted here is first to describe flash burning in detail, together with current views on methods of treatment, and then to discuss the problems of a mass burn catastrophe from atomic or chemical explosion, incendiary attack or a fire disaster.

AETIOLOGY

The cause of the burn lesion in flash burns is either heating of the tissues or, in the special case of ultra-violet flash burns, photochemical disturbances in the most superficial layers of the epidermis.

In chemical explosions the skin is burned by hot gases, which impart heat to the outer layers of the epidermis whence it is conducted downwards, and also by radiant energy from the flame of the explosion. The hot gases are believed to be mainly responsible for the injury, and the physics of burning by them has been investigated by Lidwell (1945), who has determined the quantity of heat, in calories per square centimetre, which must be transferred to the skin to cause blistering.

Flash burns from atomic bomb attacks were due to the intense radiant energy from the explosion falling on the exposed skin. Plutonium and uranium bombs released energy as particles, the most important being neutrons, and as electromagnetic waves. These were, in order of increasing wave-length, *gamma* radiation, which caused radiation sickness, and ultra-violet, visible and infra-red light. Information recently released (U.S. Atomic Energy Commission, 1950) suggests that visible and infra-red radiations, which were emitted most strongly in the first second after detonation of atomic bombs, were mainly responsible for the flash burns seen among Japanese survivors [illegible] is not [illegible] *lmost* [illegible] light [illegible] tively [illegible] *es not penetrate very deeply. This information is presented* [illegible] ble, which has been compiled from the works of several authors. Ultra-violet light entering the epidermis

produces photochemical changes which result in the liberation of toxic substances. These diffuse downwards towards the corium and presently cause vasodilation and pain, as is observed in sunburns. Visible and infra-red radiations, on the other hand, inflict damage by heating the skin. Although the immediate heating process only affects the more superficial tissues (*see* Table), the deeper layers can be injured by heat conduction downwards.

TABLE

PERCENTAGES OF TOTAL INCIDENT RADIATION OF VARIOUS WAVE-LENGTHS REFLECTED, ABSORBED AND TRANSMITTED THROUGH THE STRATUM CORNEUM AND SKIN SAMPLES ABOUT 1·5 MILLIMETRE THICK.

	Wave band							
	Ultra-violet			*Visible*		*Infra-red*		
Wave-length in microns	0·25	0·30	0·35	0·55	0·67	0·8	1·0	2·0
Stratum corneum.								
Percentage reflection	10	5	5	11	11	20	20	5
Percentage transmission	12	15	40	82	82	80	70	50
Percentage absorption	78	80	55	7	7	0	10	45
Whole skin samples:								
Percentage reflection	10	5	5	30	40	20	20	8
Percentage transmission	0	0	0	15	25	25	10	0
Percentage absorption	90	95	95	55	35	55	70	92

PATHOLOGY

Morbid anatomy

The morbid anatomy of burns from chemical explosions does not differ from that seen in other types of thermal injury. However, flash burn casualties from the atomic bomb showed certain unusual features. The depth of the burn naturally depended on the distance of the casualty from the explosion. The skin of persons exposed to the atomic bomb at Hiroshima suff[illegible]
burns at over a mile (Liebow, [illegible]
the injury inflicted became m[illegible]
complicated by *gamma* radiation sickness. The flash burns among the Japanese showed remarkable "shadow" effects, casualties being burned only where their skin was facing the bomb at the instant of detonation (British Mission to Japan, 1946). Of course, many secondary burns were inflicted by ignited clothing or fires, and these were often superimposed on the flash burns. If the flash burn casualties survived, hypo-pigmentation and hyper-pigmentation were observed both macroscopically and microscopically at the site of the burn—the so-called "Mask of Hiroshima". It has been reported that the hypo-pigmentation was observed under healed epithelium and therefore suggested that it was not due to deep burning (Liebow, Warren and DeCoursey, 1949). These remarkable pigmentation effects are not well understood, but may be related to the spectrum of the incident radiation (Blum and Teris). Infection was prevalent in Japanese flash burns due to the breakdown of medical services, and so the original injury was deepened by bacterial action and bad scarring was common (Block and Tsuzuki, 1948). Scarred burns on section showed excessive [illegible]

Clinical pathology

So far as can be judged from the published reports of the Allied observers who reached Japan six weeks after the attacks, the flash burn casualties showed clinical pathology similar to that seen in other types of thermal injury. Reports of fluid loss, infection through inadequate treatment, the formation of high granulations and scar tissue all suggest that these patients suffered the usual chemical pathological changes of burns. Thus, flash burns of more than 15 per cent of the total body surface probably suffered shock, with diminished blood volume, haemoconcentration, haemolysis, diminished urine flow, low urinary chloride excretions and salt depletion. Later in the healing phase these casualties certainly showed wasting and protein depletion due mainly to the heavy infection present on their burns. (The importance of toxic factors in burn shock (Prinzmetal and Bergman, 1945) remains unknown for man. Nor have the exact roles of "stress" response (Selye, 1950) and altered adrenal cortal activity (Talbot and his colleagues, 1947; Cope and his colleagues, 1943) been defined in the pathology *and abnormal metabolism of burns in humans.)*

SYMPTOMS AND CLINICAL COURSE

Although very little medical information concerning the symptoms and clinical course of atomic flash burns has been released, it is possible to assemble a fairly complete account by marshalling all the reports from Japan, together with certain experimental data and clinical observations on chemical explosion burns. It seems most convenient to present this account by discussing the location of flash burns, the immediate symptoms and effects of intense radiation falling on the skin, and then the subsequent course of flash burns

Location and depth of flash burns

The Japanese who suffered the atomic bomb attacks were lightly clad, so that the total area of skin burned more nearly approached the maximum possible (that is, 50 per cent of the body surface because of the "shadow" effect) than would be the case in an attack against more heavily clad people in a cooler climate. The most common locations of flash burns in Japan were the hands, face and neck, after which the bared arms and shoulders in men, and the legs in women, were the most frequent places of injury.

The depth of the burns inflicted must have been in part dependent upon the contours of the part exposed, being shallower as the angle of incidence increased (Beck and Meissner, 1947). *Some protection against flash burns was afforded* by the hair and by clothing, but it must be emphasized that burning occurred through clothing heated by the flash out as far as about 2,000 yards at Hiroshima (Surgeon-General, U.S. Army Med. Corps, 1948) and flash burns were complicated by the ignition of clothing at 1, [illegible] It should be noted that when cloth [illegible] cent of the body area. [illegible] more detail later.

Flash burns from chemical explosions are also inflicted on exposed skin, but the "shadow" effect seen in atomic flash burns is not so marked because the casualty is enveloped by the hot gases.

Immediate effects and symptoms when ultra-violet, visible and infra-red light fall on the skin

Ultra-violet light produces no immediate symptoms when it falls on the skin. The toxins released by photochemical changes diffuse downwards, however, so that after a delay of minutes or hours painful erythema or painful blistering may result. The

exact effect depends upon the wave-length of the rays. Ultra-violet radiation effects have been studied by Luckiesh (1946) but there are no experimental data concerning ultra-violet burns inflicted in such brief time periods as the atomic flash. The exact role of ultra-violet light in atomic flash burns is not known, being complicated by problems of atmospheric attenuation.

Concerning thermal radiation, infra-red and visible, experimental evidence has [illegible] sensation of heat when they fell on the skin (Oppel [illegible] these sensations by exposing the hand briefly to the radiant heat from an open fire. It seems likely, therefore, that persons at extreme ranges (3 miles) from an atomic bomb might have felt pain on their exposed skin but not suffered visible damage. [illegible] extent effect [illegible] injury at various ranges from atomic weapons, [illegible] flash burns were [illegible] d of quiescence, followed by erythema, *continuous pain, oedema and blistering. A similar delayed* appearance of blisters (hours), has been observed in animal experiments (Payne, Hogg and Pearse, 1949) *The deep burns showed immediate intense vasoconstriction* which slowly gave way to erythema, continuous pain, oedema and finally healing after sequestration of the burned skin.

[illegible]

With regard to the constitutional reactions immediately after burning injury from an explosion, some persons show primary shock with vasovagal attacks. Others show momentary confusion followed by brave expressions of mental relief that they were not more seriously injured. When they raise their hands, or head, to inspect their injury, light a cigarette or drink, they show marked tremor of the hands, lips and even head. Presently they are aware that their burns are painful.

Subsequent clinical course

[illegible] and so was related to the location of flash burns, discussed above. On the other hand, the course of the sloughing and healing phases depended upon the depth of burning, which was related first to the dose of energy falling on the skin, that is, range of the casualty (*see above*), and secondly, to the treatment the burns received. It will be shown that the treatment was bad, that infection therefore occurred on a wide scale, so that the healing phase was greatly extended.

The secondary shock phase

In a few hours oedema accumulates in the flash burned areas. If the burns involve more than 20 per cent of the body surface, the resulting loss of fluid produces clinical

signs and symptoms of shock, with apprehension, thirst, sometimes *restlessness*, sometimes apathy, nausea, vomiting, cold extremities, shivering and falling blood pressure. That these events took place in the atomic flash burns in Japan seems confirmed by the eye-witness accounts reported so admirably by Hersey (1946).

"... he [Mr. Tanimoto] remembered uneasily what the great burns he had seen during the day had been like: yellow at first, then red and swollen, with the skin sloughed off, and finally, in the evening, suppurated and smelly." "... her skin slipped off in huge glove-like pieces." "... he lifted the slimy living bodies ..." "Those who were badly burned moaned, '*Mizu, mizu!* Water, water!'" "Some were vomiting ..." "The younger one had huge raw flash burns on her body ..., she began to shiver heavily and again said it was cold.... [Presently] she was dead."

The sloughing phase

The skin burned by the flash must have separated in the next few days and weeks, depending on the depth of the burns. This stage was very painful for the Japanese casualties, presumably because they became infected. By the third day after the attack on Hiroshima there were "... only eight doctors for ten thousand patients...." "Many of the wounds were festered." By the sixth day one man's flash burns were "... covered with pus and blood ..." (Hersey, 1946). To alleviate the pain, the Japanese who were burned applied a variety of extraordinary mixtures to their lesions, potato, rice, cucumber poultices and the like, so that the widespread infection observed was not surprising. If these burns had not become infected they would not have had such long and hectic courses.

The healing phase

After the separation of the sloughs, the infection on the burns probably resulted in the necrosis of those islands of epithelium deep enough in the hair follicules and sebaceous glands to survive the original injury. Consequently partial skin loss was turned into a whole skin loss by infection. At the same time, the protein loss, as pus at the burned surfaces, must have considerably depleted the protein reserves and healing powers of the Japanese who had been on a low-protein diet through many years of war. It has been reported that some of these burns were unhealed after months or even years, and it seems possible that the keloids which appeared later in the scarred burns were due to the chronic infection and irritation.

In Japan the mortality rate for burns must have been very high due to the failure of the medical services. Many burned persons who could have been saved by medical attention probably perished in the fire-storm. Very many others must have died in [illegible] much later in the occupation. Those who did survive deep burning suffered [illegible] scarring of their hands, faces, backs, legs and other parts of the body as a result of the injury and added infection, and have become a tremendous economic loss to the Japanese community.

TREATMENT

From the foregoing it is clear that there was practically no treatment for the Japanese survivors with flash burns. Some of those whose burns were either shallow, or not extensive, survived the shock phase and were treated after a few days with local applications of mercurochrome. A very few were fortunate enough to have hypochlorite compresses applied frequently to their injuries, and these were the only casualties who did not show gross infection.

What should the treatment of flash burns be under ideal medical care? It is obvious that burn therapy has undergone several revolutions since 1900, but certain basic principles seem firmly established now for treating chemical explosion and other burns.

Pain

The outstanding symptom of flash burns appeared to be pain. This may be treated with small doses of morphine, ⅛ grain for adults, or codeine. Both of these drugs may also help to diminish the patient's psychological distress, which is always marked. The pain of flash burn is also alleviated by covering the lesion and by the local application of bland creams.

Secondary shock

Secondary shock appears in burned patients within the first 24–36 hours after injury. If the patient is suffering from shock, this must be treated immediately, before instituting local treatment.

Marked secondary shock has not been reported in first degree burns.

In second and third degree burns involving less than about 15 per cent total body surface, secondary shock from fluid loss at the burned sites can usually be prevented by oral fluids. Between 250 and 500 millilitres of chilled 1 8 per cent sodium lactate (Fox, 1944) in physiological saline (McDonald, Cadman and Scudder, 1946) by mouth each hour has been recommended for oral therapy for the first 24–84 hours in adults.

Any burned casualty with partial or whole skin loss (second or third degree burns) involving over 15–20 per cent of the total body surface is likely to suffer such losses of plasma into and from the injured areas that his circulating blood volume will presently decrease and secondary shock ensue. In addition to exuding plasma, there is evidence that the patient with extensive deep burns may also suffer reduction of his circulating blood volume by "sludging" and haemolysis of quite large proportions of his red cell mass (Shen, Ham and Flemming, 1943; Evans and Bigger, 1945; Moore and his colleagues, 1946). This is revealed clinically by haemoglobinaemia and haemoglobinuria. Thus the packed cell volume of the haematocrit, although giving a reliable indication of the extent of haemoconcentration, will not be a useful index of circulating blood volume. Taking haemolysis into consideration, it is desirable that the haematocrit should not rise above 40 in severely burned women, or above 45 in men, in the first 48 hours without instituting shock therapy.

Anuria or oliguria may also confirm an inadequate circulating blood volume, especially in patients who have lost blood from other injuries, when the haematocrit alone certainly cannot be regarded as a reliable method by which to assess shock.

The clinical features of burn shock have been examined in relation to haemoconcentration (Morrison, 1947), and it was found that the following changes occurred, in [illegible]

[illegible]

[illegible]

infusion should be started or, if already instituted, its rate must be increased, the more so as more signs and symptoms appear.

The therapeutic problem of burn shock is essentially to overcome the loss of fluid and haemolytic anaemia. The local pathological physiology of the inflammatory reaction of burns is not sufficiently well understood, yet, for the development and use of some specific substances which will counteract the vasodilation and increased capillary permeability. Nor is it certain that this should necessarily be in the patient's best interests, for the vasodilation and fluid shift may be an essential part of the defence mechanism by which the body protects itself from body constituents altered by healing (Printzmetal and Bergman, 1945). At present the extent of our therapeutic

measures are pressure bandages and replacement therapy to maintain the total *circulating blood volume*, the plasma osmotic pressure and electrolyte levels.

It has been claimed that the severity of shock can be lessened, and the injured part splinted, by the early application of pressure dressings to the burned areas, so *restricting the local fluid loss* (Mason, 1941; Allen and Koch, 1942; Rossiter, 1944). However, these methods are usually ineffective in preventing shock in burns involving more than 20 per cent body surface, especially if they involve the trunk, where firm and steady pressure is impossible due to respiratory movements.

In the second and third degree burns of over 15–20 per cent body area the chances of secondary shock are so high that it is best to augment whatever oral therapy can be tolerated with infusions of plasma and electrolytes, by needle or cannula in any suitable vein, as soon as possible. It is useful to make up the plasma with 0·5 per cent saline to combat the sodium chloride deficiency which may exist in burned patients. Various formulae have been given as rough guides to the overall intravenous fluid requirements of burned patients (Harkins and his colleagues, 1945). In the first 24 hours after burning they amount to about 1 millilitre of plasma per kilogram of body weight for each per cent of the body burned, together with an equal volume of electrolyte solution, preferably Ringer's solution. It should be noted that the rate of fluid replacement required is greatest at first and gradually diminishes. Thus about half the stated quantity of fluid is needed in the second 24 hours. However, the exact amount of the infusion always depends on the patient; the figures suggested are guides not rules. It should be remembered that some flash burns develop oedema slowly and such cases would demand slower, delayed, but more prolonged shock therapy. Shock therapy must be checked by clinical observations (*see above*), assisted whenever possible by 4-hourly haematocrit determinations and urine output records. The latter should show a urine flow of at least 30 millilitres per hour. If it does not, and in the absence of renal disease, the rate of infusion should be increased.

Cases burned in excess of 35 per cent of their body area may be unable to take fluids well by mouth, and if this is so it is necessary to infuse 1–2 litres of 5 per cent glucose in physiological saline to maintain caloric balance. In addition, it is probably good practice in deep and extensive burns to transfuse with one or two pints of fresh blood to replace the haemolysed red cells.

With very extensive burns there is a risk that any formulae may result in over infusion. Haematocrit or haemoglobin determinations are especially useful to detect this complication, which should always be suspected if the haematocrit falls below 30 in women or 35 in men, unless there are reasons to suppose that the patient was previously anaemic or unless there is a complicating injury which has caused loss of blood. Over infusion may be detected by rising jugular pressure or by the appearance of pulmonary oedema. It should be noted, however, that pulmonary complications may occur in chemical explosion flash burns due to injury of the trachea from inhalation of the hot gases (Moritz and his colleagues, 1945).

Local treatment of flash burns

Although there have been many changes in the details of local burn treatment, two major principles seem to be established. The burn should be kept free from infection, and, [illegible] permit.

Cle[illegible] al treatment. Althc[illegible] hich damages *the skin, ruptured* blister burns collect large numbers of bacteria from the air by adhesion to the coagulated serum on the surface. These invaders should be removed by gentle cleansing with a bland detergent such as cetyltrimethyl ammonium bromide (Barnes, 1942) or even soap and water. Debridement of blistered skin was generally

believed to reduce the chances of infection from organisms surviving deep in hair follicles or sweat glands, but it has been found safe to leave unruptured blisters intact (Colebrook, 1930), probably because the skin has powers to sterilize itself (Burtenshaw, 1942; Cope, 1943). In very special cases, excision and immediate grafting has been adopted, but this is most unlikely to prove feasible in any flash burn casualties.

The prevention of added infection in burns has been more or less achieved by the adoption of what may be called the "closed" method of treatment. After the burn has been cleansed, a bland bacteriostatic cream, such as that advocated by Clark and his colleagues (1943), is applied, using full aseptic precautions.

Although such an antibiotic cream will keep for several weeks in a refrigerator at + 2° C., a sulphanilamide and sulphathiazole (Colebrook and his colleagues, 1944; Wallace, 1941) cream may be more convenient in an emergency when penicillin cannot be kept in stock. Either cream layer is then covered with Vaseline gauze, sterile gauze, wool and a firm pressure dressing, all applied in such a way that the burn is completely occluded and also so that there is overlapping by the successive layers, to minimize the opportunity for bacteria to reach the wound.

It has been possible to reduce the incidence of burn infection during the time the patient is in bed in a ward, or, if the case is treated as an out-patient, while he is carrying on his normal occupation. This and subsequent, similar, dressings can be applied without anaesthesia, and if they remain intact need only be changed every 5–10 days until the sloughs separate. At this time, if the burns are deep and extensive, plastic surgery must be instituted to cover the burn with skin. The same type of dressing can be applied, with or without the penicillin cream, to the grafted areas and used until the patient is ready for discharge. There is no need for more frequent dressings providing the wound remains insulated from bacteria falling from the air after floor sweeping, blanket shaking or from direct contact with fingers. The only indications for earlier or more frequent dressings are either loosening of the bandages, dressings becoming sodden with plasma, or clinical evidence of pain, fever, tachycardia, showing that the patient may be suffering from infection of the burn despite the precautions taken.

When the dressings are changed it is important to observe the strictest precautions against infection (*see B.S P.*, Vol. 8, page 145). This is done by adopting an aseptic non-touch dressing technique, and ensuring that the burns are not exposed to air containing higher bacterial counts than is necessary. In this way the two most likely causes of added infection and cross-infection in flash burns, which caused such havoc in Japan, can be excluded. Aseptic non-touch surgical technique does not need further description here, but a few words concerning air hygiene may be appropriate. The use of the slit sampler (Bourdillon, Lidwell and Thomas, 1941) has shown that disturbance of blankets, surgical dressings, breathing without using surgical masks, in fact anything which disturbs dust or scatters respiratory droplets, can cause very high bacterial concentrations in the air This is more important in burns than most other wounds because of the area exposed to the bacteria-laden atmosphere, an area which is not only large, but sticky with serum, and an excellent culture medium. Furthermore, it has become clear that the sedimentation rate of bacteria in the air is so slow that frequent disturbances of blankets and dressings rapidly elevate the bacterial concentration in the air to very high levels. On the basis of these observations Colebrook has investigated infection in burns (Bourdillon and Colebrook, 1946; Colebrook, Duncan and Butterfield, 1947; Colebrook, Duncan and Ross, 1948) and has been led to develop a technique and plan for dressing burns in special air-conditioned rooms so that each patient's burn is exposed to as nearly sterile air as possible when it is uncovered and dressed again. All this work and the clinical results have been published by Colebrook (1950) in a monograph. In the absence of such air-conditioning facilities as Colebrook's, it is important to prevent cross-infection,

effort, meanwhile, should be made to bring the medical attention up to the standards described earlier. Unless this huge programme of satisfactory dressings and early *surgery kept burned casualties* free from the complications of infection, poor nutrition and anaemia, the eventual cost of rehabilitation would be enormous. If, by good planning and correct therapy, the majority of patients could have smooth sloughing and healing phases, the immediate strain on the medical services would be rewarded by the prevention of great and widespread distress and economic loss later.

PROGNOSIS

The prognosis in flash burns depends on many factors. The age of the patient and the area of the burns have been shown to have bearing on the mortality of a group consisting of various types of burns receiving a standard form of treatment (Bull and Squire, 1949). The mortality increased with increasing age and percentage of body burned. The same would undoubtedly be true for flash burns. The effect of depth of burning on the mortality rate has not yet been determined, mainly from lack of sufficient uniform data for statistical manipulation. An all-important determinant of prognosis is the standard of medical treatment a flash burn casualty receives, and again this standard is likely to be affected, adversely, as the number of casualties needing attention increases, unless satisfactory planning provides for the catastrophe. However, in general terms, the prognosis for the survival would be good for individual cases of uncomplicated atomic flash burns if they received adequate medical and surgical attention. The effect of concomitant *gamma* radiation on the prognosis remains, at present, an important gap in our knowledge.

(*See also British Surgical Practice* Burns and Scalds, Vol. 2, page 518, S. Key 82)

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HERNIA—RECURRENT

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INCIDENCE OF RECURRENCE

What are the results of operation for the cure of hernia? It is impossible to give a precise answer to this, but it is known from experience, gathered particularly during World War II, that the recurrence rate after operations for inguinal hernia is far too high to be disregarded. Figures published by different surgeons from different clinics show a wide variation in recurrence rate—from less than 1 per cent in some to over 20 per cent for others. There can be little value in recording here these statistics in detail, for there are so many variants affecting them. One of these is the criterion of recurrence. A small ill-defined bulge after operation may be discounted by some, and if this is done it will reduce the recurrence figure according to Grace and Johnson (1937) by about 50 per cent. Differences in accepted criteria and in other matters indeed make it irrational to conclude that because one type of operation resulted in a low recurrence rate in the hands of one surgeon, it should be applied to all hernias and adopted by all surgeons.

Great interest has been shown in the reports of the follow-up of cases operated upon at St. Thomas's Hospital, and these are recorded in full, not only because they illustrate so honestly and accurately the results of surgery in good hands at that time, but because they also give an indication of the relative merits of different operative procedures performed under identical conditions (Table I).

TABLE I

1934.

Operation	No.	Recurrence	Recurrence rate
No repair (excision of sac only)	29	4	13 8 per cent
Fowler	144	31	21·5 per cent
Bassini	36	8	22·5 per cent
Other methods	4	—	—
		Total Recurrence	20 5 per cent

1942.

Operation	No.	Recurrence	Recurrence rate
Excision of sac only	86	8	9·3 per cent
Fascia lata repair	39	6	15 4 per cent
Other methods (Bassini 7; Fowler 6; McArthur 3; Bloodgood 1)	17	3	17 6 per cent
		Total Recurrence	12·0 per cent

It will [illegible] figures that the recurrence rate had fallen by 8 per cent [illegible] especially in those of [illegible] excision of the sac are much better than those in which some plastic procedures—for example, Bassini's hernioplasty—is done as well. It may be thought that this is because only early cases were selected for the limited operation. This cannot be the whole explana-

tion, however, for there is no reason to suppose that the 1934 hernias were of longer standing and more serious than the 1942 cases, and yet only 29 of 213 cases in the first series were treated by simple herniotomy, and no less than 86 of 142 in the second series.

A further insight into the frequency of recurrence following operation may be gained by the study of figures during the late war, when no less than 805 operations for recurrence were performed during a period of six months in 1942 in four military hospitals in England. This probably represented only 60 per cent of all recurrent hernias examined, for it was found that about 40 per cent of patients previously operated upon refused a second operation. Nearly all of these patients had been operated upon the first time, and sometimes a second time, before enlistment into the Army, and they came from all parts of Great Britain and Northern Ireland. The results were, therefore, fairly representative of British surgery as a whole.

Further evidence of a high recurrence rate was obtained from a study of patients at Military Convalescent Depots. At one of these, 13 of 125 convalescents after operation for inguinal hernia were recurrent, and at another, 12 of 72 patients. From a study of these figures made in 1943, the author estimated that whatever results a surgeon may claim with his own operation in his own hands, at least 12 per cent of all male patients of military age, that is between 20 and 40 years, operated upon for indirect inguinal hernia in this country, suffer a recurrence. In other words, there are at least two failures after every seventeen operations.

INTERVAL BETWEEN OPERATION AND RECURRENCE

Most recurrences take place during the first year after operation, the incidence falling rapidly during the second year. Longacre (1939), for example, noticed that 72 per cent of recurrences took place during the first twelve months after operation, and 87 2 per cent of them within the first two years. Max Page (1934) noted that of 28 recurrences, 10 were during the first six months. In the author's series of 88 cases, 67 per cent recurred during the first year, 22·1 per cent in the second year and the remaining 14·2 per cent after the second year. Similar figures are given by Judd (1908), who *maintains that 70 per cent recurred during the first six months, and Erdmann* (1923), who, while stating that 73·9 per cent recurred during the first 12 months, makes the point that nearly 100 per cent occurred during the first 24 months. This, however, has been disputed by Mayo and Keeley (1949), who note that after McArthur's operation there was a recurrence rate of 3·9 per cent in the first year and up to 11·9 per cent in the fifth year. Ferguson (1949), who gives an over-all recurrence rate of 10 4 per cent for inguinal and femoral hernias, maintains that the recurrence rate is hardly worth quoting if given for periods under five years.

These figures are based on the evidence that patients give; that is to say, from the time they become aware of the recurrence. They are thus not indicative of the time herniation recommenced, which is probably considerably earlier. Indeed, it is likely that many recurrences begin within a few months after the patient is convalescent from operation.

CAUSES OF FAILURE AFTER OPERATION

What are the causes of failure? It must be conceded that there will always be a certain number of recurrences after operation, for accidents in surgical technique, and delays in healing, cannot easily be completely eliminated. Some of the recurrences, no doubt, are in the nature of incisional hernias, such as may follow any abdominal operation No doubt, also, the rare case in which a hernia reappears many years after an operation should not be regarded as a recurrence, but as an entirely new hernia

which would have developed in that individual irrespective of the fact that a previous operation had been performed.

Some of the factors contributing to failure are common to recurrences of all types of hernia—surgical technique; materials used; long history of herniation before operation; age of the patient and general physique; difficulties during anaesthesia; and ill-considered after-treatment. As regards indirect inguinal hernias, however, which comprise about 90 per cent of all spontaneous hernias, other factors enter into the probable causes of recurrence, and hernias of this type should be considered separately, although the factors contributing to recurrence enumerated above are naturally equally applicable to them.

Surgical Technique

It goes without saying that the less meticulous the technique the greater the recurrence rate. It should follow that the more experienced the surgeon the greater the prospect of permanent cure, but it must be confessed that attempts to prove the latter by figures have not been successful. Longacre (1939), for example, found an insignificant difference between the recurrence rate of hernia after operation by house officers and after operation by members of the senior hospital staff. None the less, it is generally agreed that hernia often is a difficult operation, and is not one which should be left to the junior house officer as an operation of an elementary character which can serve as a surgical exercise.

Technical errors

Quite a large number of recurrences of the past—perhaps now the distant past—have been due to the more obvious mistakes such as missing the sac altogether at operation, and most surgeons may recall having, during their earlier years perhaps, been guilty of this elementary error. It may be easily avoided if, when a sac is not found in the "normal" position, the inguinal canal is widely explored. Harkins (1949) opens the peritoneum at the internal ring and explores probable hernial sites, both direct inguinal and femoral, with a finger introduced into the peritoneal cavity.

The author has reason to suppose that some of the 16 cases of funicular direct hernia which are referred to on page 160 amongst 131 of recurrent hernia may have been missed at the first operation because of failure to explore the inguinal region fully, or failure to find an indirect sac. Such recurrences are, of course, apparent and not real, but in this connexion both adjectives convey the same meaning to the patient.

There are two other technical errors which may account for early recurrence. One is inefficient ligature of the sac; and the second is making a hole in the peritoneum proximal to the ligature, and failing to observe it. Evidence that errors of this kind have been made is sometimes found at operation for recurrence. If an entirely new sac of peritoneum is present, then scarring resulting from previous peritoneal ligature will be found at or near its fundus at the second operation. If, however, recurrence is due to a technical error in the ligature of the sac, peritoneal scarring will be found at the level of the internal ring, and not at the fundus of the newly developed sac.

Asepsis and haemostasis

Two matters of the very greatest importance are those of asepsis and haemostasis. Sepsis in t[illegible] region is a likely possibility unless due care is taken, and its effect may [illegible] and [illegible] to change [illegible] of the knee joint.

The strictest aseptic precautions must be taken if any foreign material is to be used to repair the hernial defect; metal, for example, should be kept in the sterilizer

until it is required; silk should have been boiled immediately before the operation; and a "no touch" technique should be followed for this particular step. The latter holds true also if fascial grafts are to be used. That floss silk cannot be sterilized by boiling perhaps accounted for the trouble it caused in 219 consecutive operations for hernia performed by the author and his colleague, W. M. Capper, during a period of twelve months at the Hernia Centre at Shaftesbury Military Hospital. Though floss silk was found a very convenient material to use, and gave a remarkably strong reinforcement of the hernial defect, yet some weeks or even months after operation the hernia scar sometimes would break down and portions of the floss silk be discharged

Relative merits of materials

There has been much discussion over the relative merits of different materials for use in hernioplasty, but it is probable that the material used is not of such supreme importance as craftsmanship. Longacre (1939) has attempted to show that the recurrence rate with catgut is greater than with silk, the difference being 12·5 per cent with the former and 3·4 per cent with the latter. Many experienced and older surgeons who have used catgut for many years will contest this. On the whole, however, unabsorbable suture material is considered preferable to catgut. Transplanted fascial sutures for hernia repair are perhaps not so popular as formerly, their place being taken by silk, nylon and other suture materials, and, in some cases, by tantalum gauze. The latter may be regarded as a modern version of the McGavin's filligree. Steel wire is the almost perfect suture material, and is finding increasing favour amongst abdominal surgeons since Babcock first introduced it for the closure of abdominal incisions in 1934. If used without tension it is absolutely reliable, and is proof against sepsis. The braided form of steel wire will be found more agreeable to use than the plain variety.

The reason for the reaction against fascial transplant is probably because of the damaging effect of the Gallie needle upon Poupart's ligament. There is also the disadvantage of the muscle hernia which follows removal of fascia from the thigh. The latter certainly proved a nuisance during war-time, for a lump which now appeared on the thigh instead of the one in the groin would sometimes be [illegible]

there was a recurrence rate of 29 1 per cent, and he therefore gave up using fascia except for the more difficult types of hernia. Sepsis was a common adjuvant cause of recurrence, but it was less when autogenous fascia was used than when ox-fascia or homogenous fascia was used. His figures for infection were very high indeed, but his criterion was very strict. The author does not think, however, that Bendick's experience has been shared at any clinics in this country.

In Williamson's excellent review (1941) of 163 operations for inguinal hernia, in most of which fascial sutures were used, sepsis was not a common complication, though it seemed responsible for recurrence in 2 patients. Behrend (1943) contends that the use of fascia reduces the risk of recurrence even in the presence of infection. The general opinion seems to be, however, that infection is more likely when fascia is used because of the longer exposure of the wound which the operation demands.

This question of duration of operation is, in fact, an important one. Beekman and Sullivan (1939), for example, state after 2,000 hernia operations that both wound [illegible]

one of these complications, each of which is a factor in increasing the rate of recurrence. Because of these various risks one would, in fact, hesitate before adopting

fascial suture as a routine, but would rather use it for the more difficult cases in which its virtues justify any possible risk of local infection.

Many ways of utilizing fascia other than Gallie's method have been practised. There is, for example, the postage-stamp fascial graft in which a rectangular section of external oblique aponeurosis is cut and used to repair the hernial defect. There is also the well-known method of Bloodgood (1919), modified by Keynes (1927), in which the anterior rectus sheath is used for the same purpose in hernia of the groin. Another example is the over-lapping of aponeurotic sheath such as is used in Mayo's operation for repair of ventral hernia. In McArthur's well-known procedure, a strip of the external oblique which forms the upper lip of the incision through the external oblique aponeurosis is used as suture material, the mesial end not being divided from its attachment to the pubic crest. Most surgeons have used this method at one time or another, and many have abandoned it because the amount of fascia obtained is not sufficient to achieve a purpose which can be more readily achieved by the use of foreign material. The recurrence rate after McArthur's operation appears to be as great as most methods based upon the Bassini principle.

Mair (1946) has used skin to strengthen the hernial region with good results. All subcutaneous fat is removed from the ellipse of skin cut for the purpose, and the graft is secured in position on the stretch. Previous experimentation on rabbits had convinced Mair that the risk of complication due to activity of buried skin elements—such as sebaceous and sweat glands—is negligible, for after a period of up to five months after implantation these elements were found to be atrophied, and hair had been surrounded by the active formation of fibrous tissue. After the lapse of such a ... determine the margin of the graft, which resembled

... of the use of tantalum gauze. In all cases the connective tissue ... n through the meshes of the gauze, rendering it impossible to separate the gauze from the tissues by dissection. Though sepsis occurred in some cases, its effect was not disastrous, for later the scars were found to be soundly healed. Throckmorton (1948) has also experimented with this material with success, and it appears to have a definite place in the treatment of very large hernial defects, and perhaps also in older people in hernias of the groin where speed at operation is of importance.

More recently Thompson (1948) has advocated for inguinal hernia the use of $\frac{1}{16}$-inch thick polyethylene plastic sheeting which can be sterilized by boiling. The sheet is placed deep to the transversalis and internal oblique muscles. Polyethylene, however, appears to be less capable of provoking a tissue reaction than ... advantage of tantalum gauze in that it ... hor it securely.

Previous history in relation to technique

It goes almost without saying that results will vary largely according to the length of history, for abdominal hernias will always tend to increase in size, the defect becoming larger and its closure more of a problem. In more extreme cases adhesions will prevent reduction, and make the operation difficult and protracted, and success not so readily obtainable. All gradations, in fact, may be seen up to the ... though largely a matter of ... guinal ... discuss ... problem does seem to ... ural history of herni... tant for him to realize that treatment by a truss rarely ... s becomes ineffective

as age advances. It thus befalls that after many years of annoyance by a truss the patient has to submit to operation after all, and at a time of life when operation is a really major performance and when success is not assured. The mere fact of wearing a truss for many years may, in fact, react against the prospect of a successful

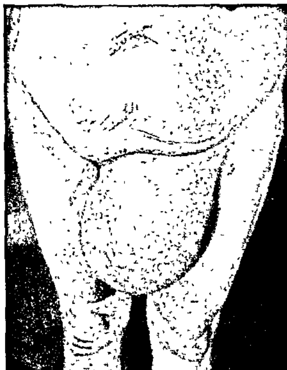


Fig 56.—Large inguinal hernia in a woman aged 50 years

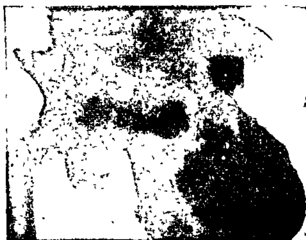


Fig. 57.—Stomach and duodenum present in a femoral hernial sac. It was later demonstrated that the distal ileum and a large part of the colon were also in the sac. (*By courtesy, Dr Cave and Brit. J. Radiol.*)

operation, for the constant pressure it exerts causes a thinning not only of the skin but of the fascial and muscular layers subjacent to it. It is safe to say, therefore, that the earlier operation is performed the less the hazard of recurrence.

Age and physique of the patient

The age of the patient, poor physique and tendency to bronchitis are factors which predispose to herniation—particularly in the inguinal region. Obesity plays a

similar role in the aetiology of all ventral herniations, more particularly, of course, in para-umbilical hernias. These factors must, therefore, encourage recurrence after operation. Their existence should not, however, be regarded as contra-indications to operative treatment. On the contrary, chronic bronchitis should be regarded in the light of an indication for operation, for sad is the plight of the older chronic bronchitic subject with a scrotal hernia which has long since defied the efforts at control by trusses of every conceivable pattern. It would be wise to add that in operating on elderly people the simplest procedures should be adopted, and in hernias of the groin, particularly the indirect inguinal hernia, such operations should be followed by the wearing of a well-fitting and light truss, although this may be criticized as a concession to the possibility of surgical failure and evidence of lack of faith.

Whether or not both sides of a bilateral case should be done at the same time will naturally depend upon the physical condition of the patient and the extent of the operative procedure intended. It has been shown that, other things being equal, there is no greater tendency to recurrence if both sides are done at one operation.

Anaesthesia

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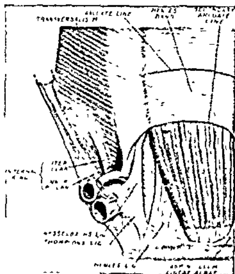


Fig. 58—Posterior view of a dissection of the lower abdominal wall. (*By courtesy, Mr. W. J. Lytle and Brit. J. Surg.*)

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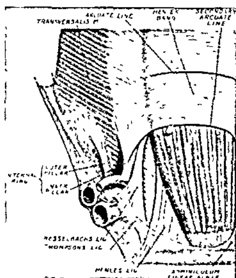


Fig 58—Posterior view of a dissection of the lower abdominal wall. (*By courtesy, Mr. W. J. Lytle and Brit. J. Surg.*)

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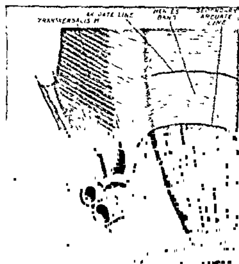


FIG 58.—Posterior view of a dissection of the lower abdominal wall. (*By courtesy, Mr. W. J. Lytle and Brit. J. Surg.*)

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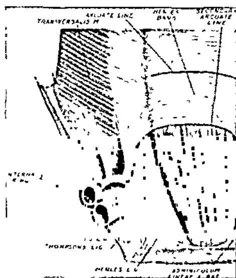


Fig 58.—Posterior view of a dissection of the lower abdominal wall. (*By courtesy, Mr. W. J. Lytle and Brit. J. Surg.*)

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the ring is safeguarded from the development of a hernia during strain. The action cannot be described as a sphincter action, nor yet as a shutter action (to which Keith likened it), but as the action of a sliding valve.

A further protection to protrusion through the ring is afforded by the overlapping of the opening by the inner margin or leaf of the ring, which takes place when intra-abdominal pressure is raised. Lytle pleads that in the early case—in which the ring has not become greatly stretched—any operation practised for the cure of hernia should safeguard both the motility of the fibrous ring and the downward movement of the transversalis muscle. He contends that the important step after high ligation

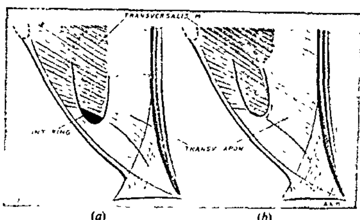


FIG. 59.—Diagrams showing the outline of the internal ring viewed from within the abdomen with the transversalis muscle (*a*) relaxed, and (*b*) in contraction. (*By courtesy, Mr. W. J. Lytle and Brit. J. Surg.*)

and excision of the sac is to narrow the deep or fibrous internal ring by suturing its pillars together, thus confirming the views expressed previously by Ogilvie (1937). The operation advocated for indirect inguinal hernia in the young muscular subject is one in which the normal anatomy is disturbed as little as possible and the muscular part of the internal ring is left inviolate. Lytle's description of the operation is as follows.

"The hernial sac is dissected from the cord and put on the stretch by pulling it forwards and outwards. The ring is not yet clearly seen because its margin is not only adherent to [illegible] points by artery forceps. It is necessary at this stage to displace the cord from its bed, [illegible] local anaesthesia the upward and outward movement of the ring can be demonstrated if tension is exerted on the forceps and the patient asked to cough. When the ring is wide, it is sutured from below by a continuous fine silk or linen thread or chromic catgut, working upwards and outwards, until the narrowed ring covers the stump of the sac and lies snugly around the cord, against the lower margin of the transversalis muscle. [Fig. 60.] While suturing, small retractors are used to hold aside the lower margin of the internal oblique. It will be noticed that the outer margin of the ring is thinner than the inner, and in placing the sutures through the outer edge care must be taken to avoid puncture of the deep epigastric artery as it turns inwards below the ring. The operation requires some practice and nicety in placing the sutures, and it is advisable to have the edges of the ring under control by artery forceps, otherwise the ring tends to fall back, and is then not easily identified. On account of frequent adherence of the ring to the neck of the sac, and

particularly where the sac is twisted prior to suture, the ring edges are often sutured by the surgeon who intends only to ligate the neck of the sac. Also, after simple ligature of the sac the ring edges may be drawn together by the process of healing, and in this way a natural narrowing of the ring takes place. Thus may be explained the good results often obtained in oblique inguinal herniae with wide necks, where the operation is limited to removal of the sac alone.

[illegible]

To displace the ring downwards alters the normal anatomy, and tends to anchor and disturb its mobility. It seems preferable, however, to repair a weak ring in this manner, than to use more difficult and doubtful methods, such as reconstruction by fascial slings."

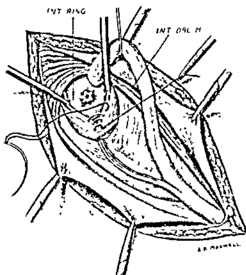


Fig. 60.—Suture of the internal ring after removal of the sac (*By courtesy, Mr. W. J Lytle and Brit. J. Surg.*)

This operation is similar to those described by Ogilvie (1937) and the author (1943), the essential feature of all of them being the avoidance of placing any sutures in the muscle which might hamper the normal working of the internal ring. It should be stressed that as little damage to normal structures as possible should be caused in the approach to the sac, and that exact anatomical reposition of structures divided in the approach should be made. The steps of the operation up to the suturing of the deep internal ring are illustrated in Figs. 61–65. Note that it is not necessary to divide the outer pillar of the external oblique which forms the lateral boundary of the external ring.

Hernias in older people or long-standing hernias in which the internal abdominal ring has become stretched

It is quite clear that in a hernia which has been down for any considerable length [illegible] has appeared in spite of it. The predisposing cause of the hernia is thus not the existence of a preformed sac, but failure of the shutter mechanism of the inguinal

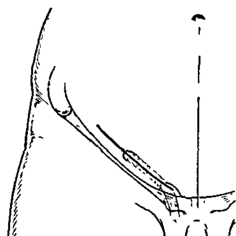


Fig. 61.—The incision. It should extend well outside the position of the internal ring, in order that the latter may be adequately exposed. (*By courtesy, Brit. J. Surg.*)

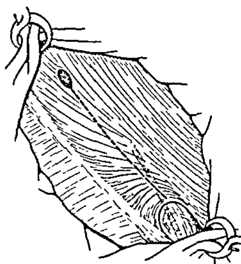


Fig. 62.—The incision in the external oblique aponeurosis is commenced lateral to the position of the internal ring and carried inwards to the external ring, which is not completely divided, to avoid injury to the ilio-inguinal nerve. (*By courtesy, Brit. J. Surg.*)

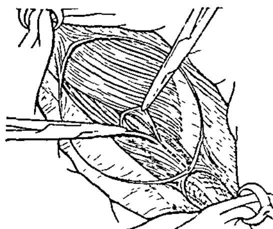


Fig. 63.—Incision of cremaster. (*By courtesy, Brit. J. Surg.*)

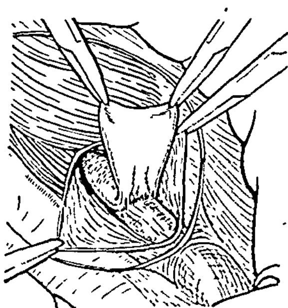


Fig. 64.—Dissection of sac. The cord medial to the sac may be steadied by holding with Littlewood's forceps. (*By courtesy, Brit. J. Surg.*)

canal, and the sac grows with the hernia. The operative cure of such hernias depends, therefore, upon a plastic operation which will compensate for the muscular failure.

Upon what should the principle of repair be based? It is thought that the Bassini method (which here includes all its modifications) is fundamentally wrong for two reasons:

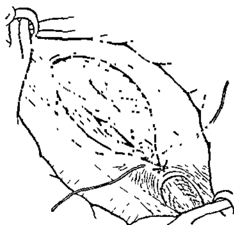


Fig 65.—Closure of cremaster and external oblique by interrupted sutures (*By courtesy, Brit. J. Surg*)

(1) It depends upon union between muscle and fibrous tissue—the arching fibres of the internal oblique and transversalis muscles as they pass inwards and in a posterior plane over the cord to form the conjoint tendon are sewn down to the tense elastic and unresponsive ligament of Poupart. It is easy at operation for recurrence after this procedure to demonstrate how little suited to marriage are these two anatomical structures. The muscle, if well developed, will wrench itself free, or if its attempt to do so fails will pine away into a thin, attenuated and poor sort of structure. These events Capper and the author observed in performing operations upon 131 examples of inguinal recurrences: 75 per cent of these were, incidentally, indirect in nature, that is repetitions of the original hernia—in fact, true recurrences. Here it may be added, more in the nature of a footnote, that Lunn (1948) has pointed out that such a construction—muscle to ligament—has no counterpart in nature, and should stand condemned on this account alone.

(2) It is quite irrational to base repair operations upon Poupart's ligament, for this lies anterior to the weak area of the abdominal ring, and though suture of the muscles to Poupart's ligament may possibly do something to prevent a peritoneal sac from getting out of the inguinal canal, it can do little to prevent it getting into the canal. It seems very probable that the cures after the Bassini types of operation occur because of high ligation and transection of the sac, and in spite of interfering with the inguinal musculature. The results from St. Thomas's Hospital bear this out (*see* page 146). Plastic operations thus should be on an anatomical plane deep to Poupart—on the plane, in fact, of the transversalis fascia. McVay (1949) contends that no operation other than Lotheissen's, in which the conjoint tendon is sutured not to Poupart's ligament but to Cooper's ligament, that is the dense fascial covering of the pectineus muscle, satisfies this requirement (*see* Fig. 66). He has during the past decade strongly advocated that what may be called the Lotheissen principle should substitute for the Bassini principle as the basis for all plastic operations for the cure of inguinal hernia when the musculature of the inguinal canal has failed. In other words, reconstruction operations for failed internal ring are better assured of a firm foundation if they are based on Astley Cooper's ligament rather than on Poupart's ligament.

Lotheissen's operation itself, however, is subject to one of the main criticisms levelled at Bassini's operation—namely that the muscular part of the internal oblique and transversalis are sewn down to tendon. Furthermore, the suture will be under considerable tension unless the conjoined tendon is "released" by incising the anterior rectus sheath, as in Tanner's modification of Bassini's operation.

The steps of the operation for this type of hernia thus should be:

(1) Wide exposure of the inguinal canal through an adequate incision, and full exploration.

(2) High transfixion and ligation of the sac. In this connexion it may be mentioned that there is no need to remove the distal portion of the sac, for this makes the operation longer and predisposes to haematoma formation in the scrotum, while conferring no benefit upon the patient. In old men, and for very large hernias, the testis on that side should be sacrificed. The cord is divided between ligatures, flush with the internal ring. There is no need to remove the testis, though the latter will be swollen and tender for some days.

(3) Narrowing of the internal ring and overlapping of the transversalis fascia of the posterior wall of the inguinal canal.

(4) Introduction of a new layer formed of foreign material or grafted tissue (fascia or skin) to reinforce this layer. It should be sutured to the edge of the rectus

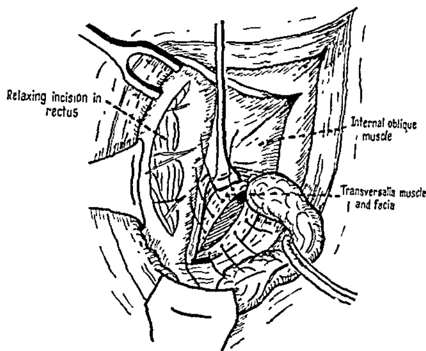


Fig. 66. Herniorrhaphy based on Cooper's Ligament. Interrupted sutures

sheath and the arching fibres of the conjoint tendon above, and below to the fascia covering the pectineus muscle. Various suitable foreign materials have already been detailed. If it is linear, for example nylon, then this layer should be a darn, and there should be no tension.

(5) The treatment of the external oblique aponeurosis is, in the author's opinion, immaterial so long as the two edges of the incision through it are completely united, leaving an external ring just large enough to transmit the cord. If there is any laxity however, as is usually the case after ablating a large hernia, the conjoint tendon may be stitched lightly to Poupart's ligament, and the excess of external oblique taken up by over-lapping.

Indications for herniotomy and hernioplasty

It will be observed that the surgeon may in certain cases be in doubt as to which operation to perform, and it is impossible to follow any rule of thumb. Harkins (1949) has given the following indications for and contra-indications to simple herniotomy.

Indications

The indications for simple herniotomy are as follows:

(*a*) All infants

(*b*) All children.

(*c*) All small indirect inguinal hernias in adults, where the muscle and sphincteric tone of the canal is good.

(*d*) Moderate-sized indirect hernias of adults where the muscles and sphincters are in a state of temporary weakness, as for example, after illness associated with onset of a hernia, but where recovery will be associated with local and general increase in muscle tone.

Contra-indications

The contra-indications to simple herniotomy include the following:

(*a*) All direct and recurrent inguinal hernias

(*b*) All large and chronic hernias where muscle and sphincteric tone in the canal has been lost.

(*c*) Where there is an associated factor predisposing to recurrence, such as chronic bronchitis.

(*d*) Obesity accompanied by muscle flabbiness and excess of extraperitoneal fat.

(*e*) All traumatic hernias.

(*f*) All sliding hernias

DIRECT INGUINAL HERNIA

The problem of the treatment of direct hernia differs from that of the indirect hernia because the protrusion is due to an acquired defect of or in the thin posterior wall of the inguinal canal The essential operative treatment is to repair the defect. The results of surgical treatment are on the whole disappointing, but this is not contrary to expectations, for unlike the treatment of congenital hernia, we are unable to eliminate the cause and are limited to repairing the weak area.

Published results show a recurrence rate of anything between 7 8 per cent (an unusually low figure referred to by McClosky and Lehman (1940)) and 35 per cent (Page, 1943) Apart from difficulties of actual operative repair, other factors exist which do explain the general high recurrence rate, the two most important perhaps being age and physique. The age incidence is naturally higher than that for indirect hernia, and the physique of the patient usually below average.

There are two distinct types of direct hernia—the diffuse (soup plate) and the funicular.

Diffuse hernia

For diffuse hernia, all operations used include over-lap of the fascia transversalis, or at least the reefing of it. Subsequent steps depend very largely upon the surgeon's inclination, but there is no question that some reinforcement is essential if recurrence is to be avoided. In most cases it is quite unnecessary to remove the sac, which is a poor affair and can readily be pushed back. Fascial transplant would appear to be suited technically to the cure of this hernia, but most of the patients are poor subjects, and it is best in them, probably, to avoid any major procedure such as is entailed in obtaining fascia from the thigh. In the larger hernias it seems likely that the use of tantalum gauze will do much to secure a sound repair. The Lotheissen type of operation—suture of conjoint tendon to Cooper's ligament—is, of course, applicable.

Funicular direct hernia

This is a very simple hernia to repair, for the hernial opening is well defined, small, rounded and comes through the posterior wall of the inguinal canal immediately

lateral to the rectus sheath. The sac is of strong peritoneum and, as a rule, well clothed with fat, closely resembling in external appearance the sac of a femoral hernia. In the author's view these hernias are similar in aetiology to Spiegel's type of hernia, differing only in that the latter is at a higher anatomical level.

Unless the surgeon is aware of this type of direct hernia he may easily miss it at operation. The possibility of its existence must be borne in mind when no sac is found in the inguinal canal on exploration for hernia which first appears after the age of 30 years; and most important of all in operations for recurrent hernia.

A very striking fact emerged from the analysis of cases at the military hospital previously referred to. Of the 16 cases of funicular direct hernia met with in 632 operations for hernia (of which 501 were first-time operations and 131 recurrent cases) 3 were "primary" and 13 were recurrent. In other words, the percentage finding of this type of hernia amongst first-time cases was 0·6 per cent and in recurrent cases 12·2 per cent. Two possible explanations exist: (*a*) the usual type of plastic repair practised for indirect hernias produces a weak area in the transversalis fascia; and (*b*) this type of hernia is frequently missed at the primary operation.

It is not known which explanation is the true one. Eight of the 16 cases occurred shortly after the first operation, 5 of them during convalescence. These were probably missed at the first operation.

Eight of them occurred some time after operation, the average period being over 2¼ years. Some of these at least appeared to have been acquired since the first operation. In one of them a silk stitch was found at the edge of the hernial orifice in the transversalis fascia, strongly suggesting that faulty technique at the primary operation was responsible. With so well-defined a sac and such a small opening in the transversalis fascia, the results of operation upon this type of hernia should be satisfactory.

FEMORAL HERNIA

The general consensus of opinion is that the results of operation for femoral hernia are superior to those for indirect hernia, and certainly to those for direct inguinal hernia. However, carefully analysed results have produced some disquieting second thoughts. Two things appear to be brought out by a study of these results:

(1) The Lotheissen type of approach is preferable to the direct approach, for through it the inguinal canal can be adequately explored.

(2) Operative procedures based on a tethering down of Poupart's ligament to Cooper's ligament on the pectineus muscle are liable to cause many disappointments. In early cases there is a preference for sewing the lower leaf of the divided transversalis fascia down to Cooper's ligament should the transversalis fascia be regarded as sufficiently strong. Where there is a large opening, however, this procedure will be quite inadequate to prevent a recurrence, and some kind of graft would appear to be necessary passing between Cooper's ligament and the conjoint tendon. Harkins (1949), following the McVay principle, suggests the use of the aponeurotic part of the internal oblique muscle, and the relief of all possible tension by dividing the anterior sheath of the rectus as described by Tanner (1942).

The method of approach through the sheath of the rectus advocated by McEvedy (1950) has much to recommend it, and many surgeons who have been privileged to see Mr. McEvedy use this approach have become converts to it.

McEvedy describes the operation in the following words.

"A vertical incision is made from just over the crural canal to 3 inches above Poupart's ligament. In the lower part of the incision the sac is thoroughly cleared. The rest of the [illegible] external ring is identi- [illegible] cision is [illegible] of the [illegible] sversalis [illegible]

fascia is very thin, and is incised so that the dissection is carried down between the transversalis fascia in front and the extraperitoneal tissue behind. The hernial sac is easily identified as a funnel-shaped structure entering the crural canal. If the sac is small it is easily drawn up; if large, it is opened below, the contents, if any, dealt with, and the sac reduced in size. In cases with strangulated intestine, the sac may be opened above and below. Having delivered the sac, it is opened, if this has not already been done. Certainly if resection of intestine is necessary there is ample room. The sac is next freed from extraperitonial tissue and on the inner side this dissection is continued until the bladder is

McEvedy recommends now stitching the conjoint tendon to Cooper's ligament, but *the theoretical disadvantages of the step have already been pointed out.*

OPERATIONS FOR UMBILICAL HERNIA

Though repair of the hernial defect by the use of fascia, as described by Gallie and Le Mesurier (1924), or by the use of the sac that has been removed, or by skin transplants, are excellent operations in the hands of their devotees, yet Mayo's operation remains the operation of choice, and is still regarded as giving the best prospect of success. The surgeon must approach this operation in the correct way. He must obtain adequate exposure through a large incision, and it is important to dissect up the sheath of the rectus so as to get an over-lap of an inch or so between the two layers. Furthermore, drainage at either angle of the wound is essential if the devastating effects of haematoma formation are to be avoided.

The treatment of the giant hernia may present many difficulties, but is beyond the scope of the present article.

INCISIONAL HERNIA

The results of treatment of incisional hernias will vary very largely according to the size of the hernia, and to the muscular defect that has been caused by the original operation. The operation is, however, usually a straightforward matter, and the results should be excellent. An important point in the technique is that which has been brought out by Cattell (1949) in the method of suture of the peritoneal lining The latter is approximated in a longitudinal direction with a continuous heavy chromic interlocking suture, including all layers of the abdominal wall, that are attached to the hernial ring (Fig. 67). This can be accomplished even when large defects are present. The large

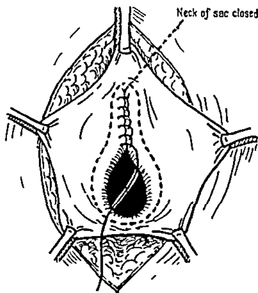


Fig. 67.—Closure of the hernia defect from the inside of the sac. Dotted line shows the line of removal of excess sac. (*By kind permission of Dr. Richard B. Cattell and the Surg. Clin. N. Amer.*)

diately overlying the first suture line.

(*See also British Surgical Practice* · Hernia, Vol. 4, page 428, S. Key 180.)

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HIRSCHSPRUNG'S DISEASE

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Since Hirschsprung's description (1888) of the disease which now bears his name, attention has been focused on the giant enlargement of the colon. In the absence of any obvious organic obstruction it was difficult to account for this dilatation. It was considered by various workers to be due to a congenital malformation, to an obstruction caused by redundancy, kinking or volvulus, to achalasia of a sphincter or to imbalance in its autonomic nerve supply.

In 1946 it was shown radiographically by Ehrenpreis that the megacolon was not present at birth, but developed during the ensuing few weeks or months. Swenson and Bill (1948) found that in twenty cases of typical Hirschsprung's disease the megacolon terminated at some point proximal to the anus, and that the intervening bowel was a spastic segment causing partial obstruction. They concluded that the megacolon was secondary to the obstruction and that, apart from its hypertrophy, it functioned normally. Their work favoured the obstruction theory, disproved the neurogenic hypothesis and dramatically focused attention on the terminal, more innocent-looking segment of bowel.

Subsequently a characteristic pathological process has been described in this segment, and the mystery which has for so long surrounded this disease is now to some extent clarified. Swenson and Bill (1948) first successfully applied the pull-through type of rectosigmoidectomy operation as the rational procedure in this disease.

Clinical picture

Boys are affected approximately thirteen times more commonly than girls. Consti-pation often begins with the retention for several days of the first meconium stools. Subsequent bowel actions are irregular and *vary in frequency from daily actions to* one in several weeks. The stools are small pellets when hard, and thin toothpaste-like ribands when soft. Large amounts of flatus are passed and gaseous abdominal dis-tension appears early though it may pass unnoticed at first.

Obstructive crises with vomiting, sudden abdominal enlargement and [illegible] occur in about two-thirds of the cases in the first 6 months. The child [illegible] hydrated and weight loss is often extreme. The abdomen is tense, [illegible]. These attacks may be relieved spontaneously or require bowel [illegible].

If the child survives these early precarious days the disease [illegible]. Bowel actions are irregular, and frequent suppositories, [illegible] necessary. The upper abdomen becomes permanently [illegible] [illegible] abdomen and borborygmi are frequently heard. [illegible] appears normal, the anal canal is long and [illegible]. Through the rectal wall large faecoliths may [illegible].

Malnutrition varies with the severity of [illegible]

measures instituted to overcome it. Microcytic anaemia, occasionally of severe degree, and recurrent putrefactive crises occur in the chronic stage.

Superimposed upon this state of chronic partial obstruction are frequent acute attacks. Some culminate in serious faecal impactions which require skilful repeated bowel irrigations for relief, and others are relieved spontaneously.

Untreated cases of Hirschsprung's disease rarely reach adult age or even adolescence.

Pathology

Zuelzer and Wilson (1948), Bodian, Stephens and Ward (1949), Whitehouse and Kernohan (1949), Swenson, Rheinlander and Diamond (1949) have now published similar uniform findings in a considerable number of cases of Hirschsprung's disease.

On examination *post mortem* or at operation the dilated and thickened bowel is pale in colour, contains gas and faecal material and the mesentery is long and contains enlarged lymph glands. The bowel appears redundant. Distal to the enlarged bowel, the intestine assumes a more normal or narrow calibre and thickness. The transition between enlarged and normal calibre is sudden and funnel-shaped and takes place in 60 per cent of cases in the distal sigmoid or rectum, and in the remaining 40 per cent

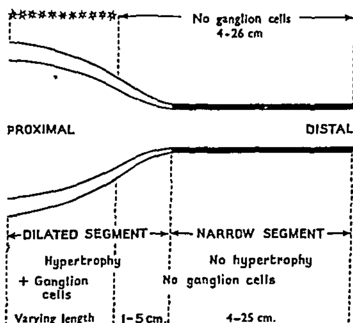


Fig. 68.—Pathology of 28 cases of Hirschsprung's disease with narrow segment. (*By courtesy of Lancet.*)

at some more proximal point. This segment, distal to the dilated bowel, appears normal to the naked eye and has been regarded as such for many years. When it involves only the rectum it is not apparent without dissection in the pelvis. If it extends into the rectosigmoid region or more proximally, this apparently normal [illegible] faeces.

[illegible] ation the [illegible] ganglion

intramural plexuses of Auerbach and Meissner are found to be [illegible] ganglion cells. *The* aganglionic bowel extends from the anus, throughout the distal segment, and continues for 1–5 centimetres into the funnel-shaped transition zone (*Fig.* 68). There is no evidence of inflammatory reaction and the condition is regarded as a congenital aplasia of the ganglion cells. Non-medullated nerve bundles, *sometimes of*

considerable size, are seen in the sites of the intramural plexuses. The origin of the nerve fibres has not been established. Both the absence of ganglia and the presence of those nerve bundles are abnormal features and are characteristic of Hirschsprung's disease.

The dilated segment when examined microscopically is found to consist of hypertrophied muscle coats of the bowel, with normally arranged ganglia in the intramural plexuses.

The functional manifestation of the aplasia is absence of the peristaltic movement in this segment, which fails to propel the faecal stream. This absence of peristalsis in the distal segment was demonstrated in eight cases of Hirschsprung's disease by Swenson, Rheinlander and Diamond (1949) in their studies of colonic motility using a multiple balloon technique. They showed also that this segment possessed increased tone.

X-ray diagnosis

Swenson and Bill (1948) and Swenson, Neuhauser and Pickett (1949) first described the typical radiographic appearances of Hirschsprung's disease. They were able to demonstrate a terminal narrow spasmodic segment distal to the megacolon in all their cases of Hirschsprung's disease. The plain x-rays of the abdomen reveal gaseous distension of the bowel, particularly of the colon, though in the first few weeks it is more evenly distributed. The gas-filled gut can be seen bulging the flanks and raising one or both sides of the diaphragm.

Barium enema examination in the chronic stage of the disease reveals characteristic features. It is necessary to introduce small amounts of barium emulsion slowly during the screening in order to avoid obscuring the distal segment by superimposed barium in the dilated bowel. Observations in the antero-posterior, oblique and lateral views will demonstrate the pathological segment when present. This segment is of variable length and extends from the anus most commonly to the rectosigmoid or distal sigmoid region. It is normal or narrow in calibre and is seen in some cases to undergo a type of segmentation similar to that seen in the small bowel. Proximal to this segment the calibre of the bowel rapidly enlarges in a funnel-like manner to become the typical megacolon (Fig. 69). The dilatation is maximal immediately adjacent to the funnel The degree of dilatation and the length of the dilated bowel presumably depends on the degree of obstruction offered by the terminal segment. In the dilated bowel faecoliths and fluid levels may be visualized.

In the newborn period, the gaseous distension is more evenly distributed through the bowel and the contrast between the terminal narrow calibre and the dilated bowel is not easily seen. Radiographically, at this stage, the diagnosis may be impossible, and repeated examinations at monthly intervals may be required. Ehrenpreis (1946) demonstrated the gradual appearance of the typical megacolon in 4 newborn children in the course of periods of from 18 days to 3½ months.

Differential diagnosis

Stricture of the anus

Obstinate constipation due to an organic stricture of the anus is diagnosed by simple rectal examination. The bowel above the stenosis dilates considerably and becomes filled with faecal accumulations. Radiographically, the dilated colon is indistinguishable from that seen in advanced idiopathic chronic constipation as the anal stricture is difficult to demonstrate.

Chronic constipation

Idiopathic chronic constipation has been confused with Hirschsprung's disease because of the constipation, faecal accumulation and dilatation of the colon. This

condition has a different clinical pattern and radiological appearance, and a benign course (Bodian, Stephens and Ward, 1949).

Boys and girls are affected in the proportion of 2 to 1. Although mild constipation may occur from birth, the onset of a more severe form is usually after some months or years and usually follows a dietetic upset, an acute illness or a change in the child's routine. Bowel actions are at first hard and large in diameter, accompanied by straining and pain, and often a streak of blood is reported in the motions. Fear of defaecation, voluntary holding-back and abdominal colic ensue. Eventually routine

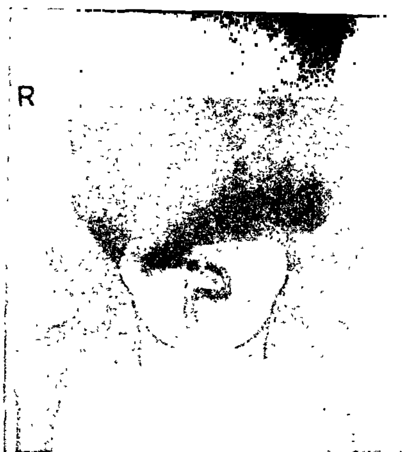


FIG. 69.—Barium enema x-ray demonstrating the narrow segment distal to the dilated bowel.

bowel actions become infrequent, and the constipation gives way to a continual or intermittent faecal leakage which soils clothes and sheets On examination the child, though temperamental, is in good general health. The abdomen is moderately enlarged with hard faecal masses in the distended sigmoid colon, palpable in the suprapubic and umbilical regions. On rectal examination the anal mucosa is often split and soiled, the anal canal short and the rectum is distended to capacity with hard faeces. Sometimes the anus is stretched over the faecal mass which is visible on parting the buttocks.

Barium examination shows the rectum to be dilated as far distally as the anus and the dilatation may extend proximally to include the distal half of the sigmoid forming a terminal reservoir type (Fig. 70), or it may extend throughout the redundant sigmoid in the form of a tubular dilatation.

This condition is benign and in the early stages may subside spontaneously. Without treatment or with inadequate measures the symptoms may persist for many years.

Treatment consists of initial thorough evacuation by washouts or, when the masses are very hard, manual disintegration under anaesthesia. This is followed by a 5–7 weeks' course of bowel washouts, 3 times weekly for 3 weeks, twice weekly for 2 weeks, and then once weekly for a further few weeks depending on the progress. These washouts (not enemas) are necessary despite spontaneous bowel actions occurring during this period. A good purgative to keep the stools soft and regular, and re-training in the normal bowel régime are essential during the course and for some weeks or months afterwards.

To summarize, therefore, this condition differs from Hirschsprung's disease in the following features: later onset, larger diameter motions, painful defaecation, faecal



(a) (b)

FIG 70—Chronic constipation with megacolon (a) Barium enema skiagram demonstrating terminal reservoir in antero-posterior view. (b) Lateral view showing dilatation of the bowel *extending distally to the anus.*

leakage, benign course, satisfactory response to conservative treatment and dilatation of the bowel from the anus proximally without any terminal intervening segment which is narrow or of normal calibre.

Other conditions

Other medical conditions such as cretinism cause constipation, but this is rarely the presenting symptom and the constipation responds to the treatment of the primary condition.

Treatment

In the past the reports on the various forms of treatment for Hirschsprung's disease have been conflicting. This was due, presumably, to the confusion caused by using the

term megacolon, which includes cases of idiopathic chronic constipation as a synonym for Hirschsprung's disease.

In a follow-up of 39 cases of Hirschsprung's disease by Bodian, Stephens and Ward (1949) no cases were cured. Eleven of the children had succumbed. Various forms of conservative medical treatment had been applied with only temporary, if any, improvement. Spinal anaesthetics and sympathectomy operations caused no more than temporary relief of symptoms. Excision of part or whole of the dilated colon was followed by recurrence of *all the obstructive phenomena in the bowel proximal to the anastomosis*. A colostomy performed in the dilated bowel was found to function normally.

Swenson and Bill (1948) studied 20 cases of Hirschsprung's disease and from their observations devised an operation called rectosigmoidectomy to remove the terminal "spastic" segment, conserving the megacolon, and *anastomosing this dilated bowel to* the anus with preservation of the sphincter mechanism.

The pull-through rectosigmoidectomy operation described below embodies the principles suggested by Swenson and his colleagues (1948–1949), but varies in some points in technique.

The procedure is staged into a preliminary defunctioning transverse colostomy followed, when the general health of the child is optimal, by the rectosigmoidectomy operation, and then closure of the colostomy.

Colostomy

The colon is first emptied by bowel washouts. These are repeated daily for about a week. Hard faecoliths, which necessitate manual disintegration under anaesthesia, may become apparent after removal of the faecal mud and gas.

It is usually possible to tide over severe obstructive phases by washouts. The passage of the tube through the terminal segment is often more difficult in the obstructive phases because of kinking of the bowel at the transition site and because of compression of the narrow segment by the loaded megacolon which wedges itself in the pelvis. The introduction of the tube is facilitated by guidance with the index finger.

During the course of washouts the child improves in health, the appetite returns and the operative risk is much diminished.

The distal bowel is then explored through a right upper rectus muscle-splitting incision and the *junction of the dilated and narrow colon is demarcated* with two black sutures. If the junction is in the pelvis it may not be visible at this operation. If any [illegible]

[illegible]

[illegible] colostomy in the transverse colon. To prevent prolapse in the early and later [illegible] operative periods in children whose straining is sometimes uncontrollable, the peritoneum is sewn to the thick-walled colostomy loop. The opening in the abdominal [illegible] made large enough to admit only the fifth finger through the colostomy stoma. [illegible] *at the end of the operation.* [illegible] faeces into the defunctioned segment, [illegible] our and left *in situ* until after the rectosigmoidectomy operation. On the sixth day after the operation *the defunctioned* segment is washed through, and this procedure is repeated daily until the return is clear. Up to 3 months is allowed to elapse before the rectosigmoidectomy operation is performed.

Rectosigmoidectomy

The preliminary preparation for the rectosigmoidectomy consists of further distal colon irrigation and daily installation of sulphathaladine suspension for 5 days. Penicillin given systemically *and by local instillation* is commenced the day prior to

operation, and streptomycin is given post-operatively when indicated. An intravenous infusion is commenced prior to operation and changed to blood transfusion as required. Endotracheal ether, with nitrous oxide when the diathermy is used, is a convenient anaesthetic.

The child is placed in the combined lithotomy and Trendelenburg position to gain simultaneous access to the abdomen, pelvis and perineum. For babies under two the infant's operation frame is very satisfactory (Fig. 71).

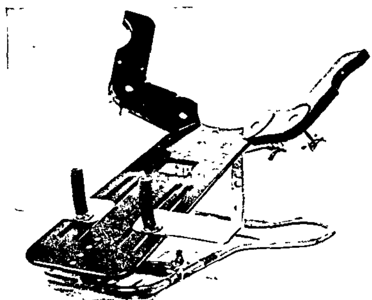


Fig 71.—Infant's operation table (made by The Medical Supply Association, Ltd., London) for abdomino-perineal surgery of children under 2 years of age.

The afferent colostomy stoma is occluded with a suture for the duration of the operation, and the bladder is drained with a urethral catheter which is retained for twenty-four hours after the operation.

Through a left lower paramedian incision the distal colon can be adequately explored. The pale thick-walled redundant megacolon in the collapsed state is easily recognized and the site of transition between dilated and narrow bowel is identified. If the transition occurs in the pelvis it may not be seen until after the bowel is dissected from its peritoneal covering.

It has been found that there is sufficient redundancy of bowel to permit the pull-through type of resection of the pathological segment. The colic and marginal vessels are long in proportion and adequate in size and length to supply the hypertrophied bowel when displaced to its new site.

The pathological segment includes all the terminal normal-calibre bowel and extends to approximately half-way up the cone-shaped dilatation. The site for resection is, therefore, at some convenient site proximal to this point depending on the vascular arrangement and the redundancy of the bowel. This point is marked with two more black seromuscular sutures.

The colic vessels supplying the pathological segment are ligated and divided. The [illegible]

and lengthen on straightening, together with the marginal vessels. The superior rectal

artery is then doubly ligated with linen thread and divided at the brim of the pelvis, after ensuring the safety of the ureter.

The peritoneum is divided along the lateral aspect of the narrow segment and across the front of the rectum deep in the pelvis. This bowel and rectum is then cored out of the supporting tissues so as to disturb the remaining pelvic organs and nerves as little as possible. The blood vessels entering the rectal wall are under-run with right-angle forceps and divided with the diathermy on the longitudinal muscle coat. The dissection must be kept right against the bowel.

The bowel is entirely freed distally as far as the levator ani attachments, posteriorly and laterally, and to the apex of the prostate anteriorly (Fig. 72). The abnormal

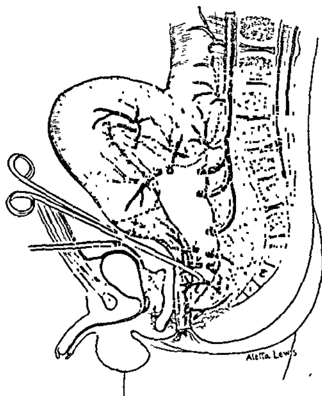


FIG. 72.—Freeing of the bowel.

segment is then intussuscepted through the anus using the sigmoidoscope and sling method described by Denis Browne (1949) and illustrated in Fig. 73.

At this stage the peritoneal floor and abdominal wall are reconstituted.

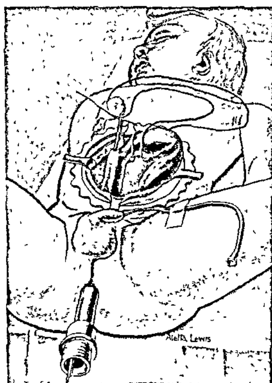
The prolapsed bowel is then washed with antiseptic. The outer wall is incised longitudinally to within an inch of the anocutaneous junction, and through the opening the inner segment is withdrawn until the demarcating sutures come into view.

The inner segment is then opened permitting the introduction of the sigmoidoscope to distend its lumen. Four non-strangulating, equally spaced, guide sutures are inserted on heavily curved needles through all coats of both layers of bowel half an inch from the anocutaneous junction.

The prolapsed bowel to within half an inch of the anocutaneous line is then excised with the diathermy and sutured with interrupted muscle and mucosa apposing linen sutures (Figs. 74 and 75). The anastomosed bowel is reinserted inside the anus and the guide sutures are left long and protruding from the anus, so that the suture line can be retrieved in the event of haemorrhage.

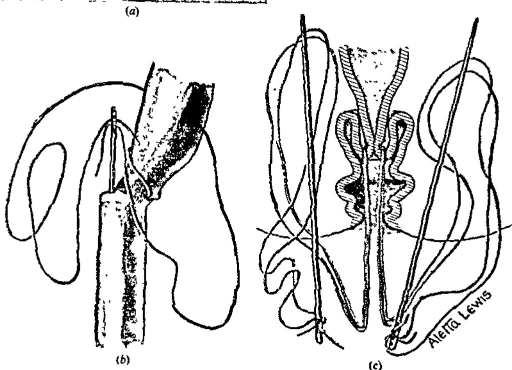
On the twelfth post-operative day, if digital examination of the anastomosed region is satisfactory, the Perspex rod is removed. The spur-crushing clamp is applied on the fourteenth day and formal closure of the colostomy is performed a week or two later.

When symptoms are mild, Swenson has performed the operation with success in one stage. The technique here described does not follow Swenson's original description



(a)

FIG 73.—A sigmoidoscope is introduced through the anus into the freed bowel. [illegible]



(b)

(c)

artery is then doubly ligated with linen thread and divided at the brim of the pelvi[s] after ensuring the safety of the ureter.

The peritoneum is divided along the lateral aspect of the narrow segment an[d] across the front of the rectum deep in the pelvis. This bowel and rectum is the[n] cored out of the supporting tissues so as to disturb the remaining pelvic organs an[d] nerves as little as possible. The blood vessels entering the rectal wall are under-ru[n] with right-angle forceps and divided with the diathermy on the longitudinal muscl[e] coat. The dissection must be kept right against the bowel.

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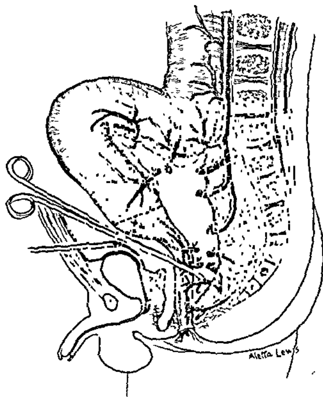


Fig. 72—Freeing of the bowel.

se[g] ... ...ated through the anus using the sigmoidoscope and sling
m[e] ... ated in Fig. 73.
... all are reconstituted.

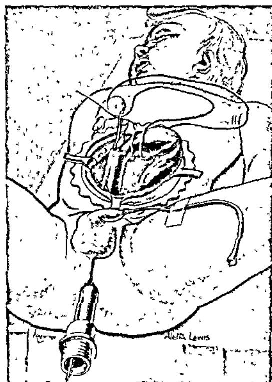
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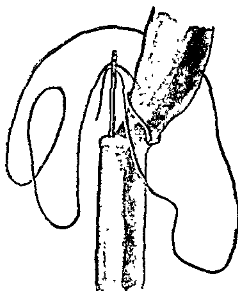
When symptoms are mild, Swenson has performed the operation with success in one stage. The technique here described does not follow Swenson's original description



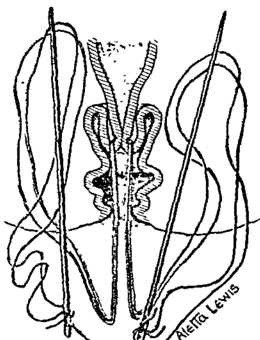
(a)

Fi [illegible]

Society of Medicine)



(b)



(c)

of the operation in the following points. He divides and oversews the bowel within the abdomen and pulls it through subsequently. For the anastomosis in the perineum he uses 2 layers of sutures for the muscle and mucosa.

Results of surgery

The results of this form of surgery are most encouraging in the early follow-up of up to 2 years' duration. The bowels evacuate spontaneously and without straining. Abdominal distension is absent or mild and easily relieved by passage of flatus. The

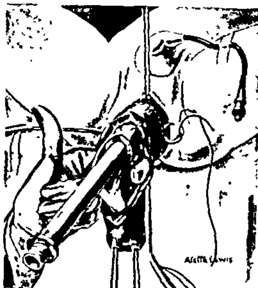


FIG. 74.—Suture of the prolapsed bowel. (*By courtesy of the Annals of the Royal College of Surgeons.*)

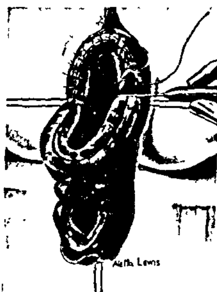


FIG. 75.—The cutting of the double layer of bowel by [illegible] needle and its sewing by linen [illegible]

older children appear to have an adequate rectal sensation and a normal urge to defaecate.

The radiological appearances confirm the clinical observations though the actual diameter of the bowel is still slightly above normal after 12 to 16 months.

The rationale of the operation devised by Swenson and Bill for Hirschsprung's disease is confirmed by the follow-up results.

Complications of the operation

In a series of 34 cases treated at the Hospital for Sick Children, Great Ormond Street, there were 2 operative deaths and 1 post-operative.

Three children, though not incontinent of faeces, soiled themselves for several months. [illegible] completely recovered and the third continues to soil. One child develope[illegible] recovered completely. [illegible] some months.

Three patients have recurrence of symptoms. One is unable to evacuate spontaneously. Two have intermittent distension necessitating in one a bowel washout from time to time. In these three children too much pathological bowel adjacent to the anus remains and still causes a hold-up of the faecal stream.

Alterations in the technique designed to overcome these complications are incorporated in the above description of the operation.

See also British Surgical Practice Colon—Developmental Abnormalities and Megacolon, Vol. 3, page 130, S. Key 99.)

ACKNOWLEDGEMENT

I wish to thank the physicians and surgeons of the Hospital for Sick Children for their help and co-operation in the management of these cases. I am most grateful to Dr. Martin Bodian for permission to use his pathological data, and to Dr. B. C. H. Ward for his co-operation in the radiological studies.

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SPONDYLOLISTHESIS

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DEFINITION

Spondylolisthesis is a disability of the lower lumbar spine arising from a specific defect in a lumbar vertebra, usually the fifth. The clinical manifestations are incapacitating low back pain and characteristic deformity.

Spondylolisthesis is not a common condition. Furthermore, its recognition is hampered by the fact that of those individuals who possess the vertebral defect which is the essential pathological lesion, only a fraction present themselves with symptoms and signs which lead to a diagnosis. The opportunity to accumulate clinical experience, therefore, is limited. There is still much to be learned about the condition, especially in respect to aetiology, diagnosis in the earliest stage of the deformity and refinements of operative treatment.

PATHOLOGICAL ANATOMY

Most cases of spondylolisthesis (but not quite all) are the result of a defect in the structure of a vertebra, usually the fifth lumbar. The defect is an interruption in the bony neural arch, at the narrow portion between the articular facets known as the isthmus or pars interarticularis. In life the defect in the bony ring is filled with a bond of fibrous tissue. In dried specimens the fibrous bond disappears during preparation and the vertebra separates into two portions: (1) a posterior fragment consisting of the lamina, spinous process and inferior articular facets and (2) an anterior fragment consisting of the body, pedicles, transverse processes and superior articular facets (Fig. 76). This defect is visible in lateral radiographs of the involved vertebra (Fig. 77).

The vertebra involved is the fifth lumbar in the great majority of cases. Other lumbar vertebrae may be involved with diminishing frequency from the fifth lumbar vertebra upward, and occasional cases have been reported at higher levels. The lesion is essentially a disease of the lumbo-sacral region. In a personal series of 100 consecutive cases, the distribution was: lumbar five, 92 cases; lumbar four, 8 cases. Friberg's (1939) 290 cases were distributed as follows: lumbar five, 197; lumbar four, 75; lumbar three, 14; lumbar two, 3, lumbar one, 1. Occasionally 2 vertebrae are involved, usually lumbar four and lumbar five.

While the defect in the neural arch is commonly bilateral, it is occasionally limited to one side. Dia[illegible] the deformity is slight and the unilateral de[illegible] are taken (Fig. 78). [illegible]

The presence of the characteristic defect in the neural arch renders the fifth lumbar vertebra unstable in relation to the sacrum. Normally the inferior articular facets of the fifth lumbar vertebra are hooked over the superior articular facets of the sacrum in such a manner as to anchor it firmly to the sacrum. When its bony structure is intact and its inferior facets are locked over those at the top of the sacrum, the fifth [illegible] If the defect of spondylolysis [illegible] fifth lumbar vertebra and its [illegible]n held in place only by the [illegible] fibrous bond which fills the defect at the pars interarticularis. Of these attachments, the last is the most critical.

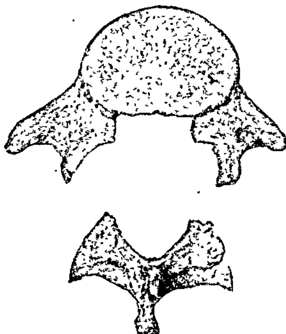


FIG 76.—The characteristic defect of spondylolisthesis (fifth lumbar vertebra). Interruption of the neural arch on either side at the isthmus. The anterior fragment consists of body, pedicles, transverse processes and superior facets, the posterior fragment of laminae, spinous process and inferior facets.



FIG 77.—Lateral radiograph of spondylolisthesis of fifth lumbar vertebra with moderate slip.

It may prove sufficiently strong to *resist the stresses* incidental to movement and the support of body-weight. Then the patient lives his life without symptoms, without deformity and without consciousness of his defect. On the other hand, under the stresses which play upon it, the fibrous bond may slowly *stretch* and give way or it may be disrupted by a single injury or repeated injuries. Once the syndesmosis is stretched or disrupted, the body of the fifth lumbar is no longer anchored securely to the sacrum. Movement and superimposed weight *separate it* from its inferior



FIG. 78.—Oblique radiograph. A view which is useful to depict the defect in the neural arch when there is no displacement.

articular facets and push it downward and forward across the sloping upper surface of the sacrum. The amount of forward displacement of the body of the involved vertebra and consequent separation from the posterior fragment which is left behind varies considerably. It may be so great that the body of the fifth lumbar vertebra falls completely off the top of the sacrum and comes to occupy a position on the anterior surface of the sacrum.

We must distinguish between two groups of cases: (1) spondylolysis or pre-spondylolisthesis in which the characteristic defect exists in the neural arch but is unaccompanied by any forward displacement of the body of the vertebra (Fig. 80); (2) spondylolisthesis: those cases in which the defect is accompanied by forward slip of the vertebra (Fig. 77). As there is a rough parallelism between the degree of slip and the severity of symptoms and deformity, it is customary to grade the displacement. The significant degrees are (1) defect present but no displacement (spondylolysis); (2) moderate displacement (up to one-half the diameter of the body of the vertebra); (3) severe displacement (more than one-half the diameter of the body but still on top

of the sacrum); (4) maximum displacement, the body is completely off the top of the sacrum and lies on the anterior face of the sacrum.

Spondylolysis may exist without any symptoms. Such cases must account for the great discrepancy between the incidence of the lesion in anatomical museums and the number of cases recognized clinically. Spondylolisthesis almost invariably is the cause of symptoms though frequently the degree of disablement is much less than might be expected from the disruption of the vertebra revealed in the radiograph.

Another and entirely different mechanism occasionally results in spondylolisthesis. In such cases there is a deficiency in the size or an imperfection in the shape of the inferior articular facets of the fifth lumbar vertebra which renders insecure their grasp of the superior articular facets of the sacrum. In time the defective articulation may be dragged apart; the inferior facets of the fifth lumbar vertebra are pulled over or through the superior facets of the sacrum. This is, in fact, a dislocation. Once the facet articulations are unlocked, the entire vertebra is adrift. It slips forward under the stress of movement and the superimposed body-weight just as does the body of the vertebra with the more common defect at the isthmus of the neural arch. While this mechanism does result in spondylolisthesis in the strict derivational sense of the term, it is a rare occurrence (2 per cent in the author's series).

FREQUENCY OF OCCURRENCE OF THE DEFECT AT THE ISTHMUS WHICH PERMITS SPONDYLOLISTHESIS TO OCCUR

Since the studies of Willis (1931), it has been recognized that the defective neural arch (spondylolysis) occurs with surprising frequency in the skeletal material in anatomical museums. His figures were: 79 cases among 1,520 skeletons (5 per cent). A similar proportion exists in the material in the anatomical museum of the University of Toronto. The essential defect is common and its incidence is much higher than is clinical recognition of the syndrome. This suggests that not all cases of spondylolysis

the detect must have been present before the injury. There is evidence, therefore, that the cases of spondylolisthesis which we recognize clinically and diagnose are only a small proportion of the individuals who have the defect at the pars interarticularis.

AETIOLOGY OF SPONDYLOLISTHESIS AND THE RELATION TO IT OF TRAUMA

Little is known regarding the manner in which the defect in the neural arch arises. Generally it is assumed that the defect is congenital, the result of an aberration in the ossification of the vertebra. But our knowledge of the ossification of a vertebra does not justify the assumption that the defect could develop from failure of fusion of normal centres of ossification. The normal primary centres of ossification are three: one for the body and one for each half of the neural arch (Fig. 79). At birth these centres are still separate and their points of contact are completely unrelated to the site of the de

The work

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mality of ossification. It must be concluded from this that the lesion develops after birth, for a corresponding number of adult spines would have shown about 10 cases of the defect. The lesion is recognized occasionally in early life; the earliest being Kleinberg's (1934) case at 17 months. Occasionally spondylolisthesis occurs in parent and child,



FIG. 79.—Lumbar vertebrae of a newborn child. Three centres of ossification: (1) body; (2) right half of neural arch and (3) left half of neural arch.

FIG. 80.—Lateral radiograph showing spondylolysis of fifth lumbar vertebra with no displacement. It shows the relationship of the inferior facets of the fourth lumbar vertebra to the defect in the neural arch of the fifth, which suggests the possibility that on hyperextension of the spine they can act as wedges to disrupt the fibrous bond at the defect in the neural arch.

suggesting at least a familial weakness which permits the deformity to develop. The most remarkable example of heredity in relation to spondylolisthesis is Friberg's (1939) record of the examination of a family of 4 generations. Of 64 descendants of a man suffering from spondylolisthesis 60 individuals were examined. Of these 15 (including the propositus) suffered from spondylolisthesis (24.6 per cent). In the third [illegible] with the same [illegible]s. Examination for evidences of heredity in spondylolisthesis has seldom been carried out. It is conceivable that much new information might be obtained by mass survey of selected segments of the population.

Some evidence has been advanced to suggest that the defect may occur as the result of injury at birth or in early life (Hitchcock, 1940). It is assumed that severe hyperextension of the spine during infancy, such as might occur during a breech delivery, can cause the inferior articular facets of the fourth lumbar vertebra to impinge upon the pars interarticularis of the fifth with sufficient force to disrupt the neural arch at this point (Fig. 80).

It must be admitted that we know little of the conditions which give rise to the defect in the neural arch at the isthmus which is the essential lesion of spondylolisthesis. Much further study upon this aspect of the problem is needed with the prospect that entirely new concepts will develop from it.

However uncertain the part that trauma plays in the causation of the primary defect in the neural arch, it seems definite that often it is the final factor determining the onset of symptoms. Many patients with spondylolysis have no disability of the back until subjected to a single specific injury, often one in which the spine is hyperextended or one in which a strong force is exerted vertically downward upon the spine. From history and clinical observations it seems an inescapable fact that the symptoms, the deformity and the disablement of spondylolisthesis can be initiated by injury.

The frequency with which symptoms are initiated by a hyperextension injury may be of important significance. The relationship of the inferior facets of the fourth lumbar vertebra to the isthmus of the fifth lumbar vertebra are such as to suggest that hyperextension may force these facets downwards into the isthmus of the fifth and crack it open as by a wedge (Fig. 80). If this occurred in an intact vertebra, it would be a fracture. But the defect does not behave like a fracture; it never, for instance, shows any signs of repair. Rather than fracture, it seems more likely that the effect of the hyperextension injury is to disrupt a neural arch which already has the characteristic defect of the bony ring (spondylolysis). Up to the moment of injury the fibrous bond has been sufficiently strong to resist ordinary stresses. Once it has been forced apart by hyperextension or by any other force, it is weak, unstable and can no longer withstand normal stresses.

In a series of 100 cases of spondylolysis and spondylolisthesis, in 55 the onset of symptoms was related to injury which in 16 cases was a hyperextension injury.

CLINICAL MANIFESTATIONS OF SPONDYLOLISTHESIS

The clinical manifestations of spondylolisthesis group themselves under two headings, pain and deformity. Both are dependent upon the instability and the displacement of the involved vertebra and their degree is roughly proportional to the amount of slip. The greater the slip the greater the number and severity of signs and symptoms.

Pain

Pain is the symptom which most commonly attracts attention to spondylolisthesis. It appears in two forms. backache due to weakness and instability of the lumbosacral articulation and sciatic pain due to pressure upon the roots of the sacral plexus.



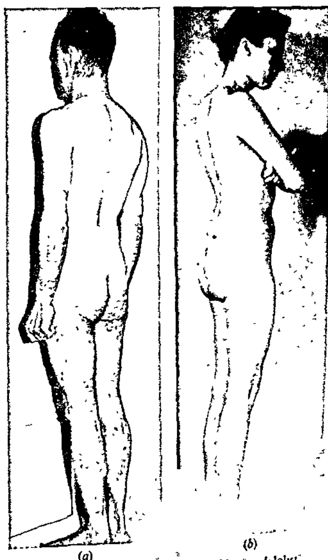
IG 81 —Spondylolisthesis of fifth lumbar vertebra with severe changes in the disc between L 5 and S 1 Note also the distortion of the intervertebral foramen



FIG. 82.—Post-mortem specimen recovered from a patient who died of carcinoma six years after lumbo-sacral fusion for spondylolisthesis. Right and left oblique views which show the deformity and on the right side the extreme narrowing of the intervertebral foramen between L.5 and S.1 (arrow points to intervertebral foramen). On left side foramen is greatly diminished in size but is larger than on right side.

the spinous process of the involved vertebra being farther back than those above it (Fig. 83 (*a*)). When present and visible, this abrupt jog in the alignment of the spines is very distinctive. Sometimes it is obscured by obesity and can only be felt.

In sliding forward the involved vertebra carries with it the trunk above. This displaces forward the centre of gravity. To compensate for this the lumbar spine is hyperextended and the upper part of the trunk is thrown backwards.



(*a*) (*b*)

FIG. 83.—(*a*) Photogra... to show a characte... step-like jog in the ... processes. The prom... vertebra. (*b*) Illustra... spondylolisthesis. Th... superior spines have ... with spondylolis... ity ... sp

In an attempt to realign the weight o... the pelvis is rotated about a transverse ... The obvious indication of this is the ele... of the posterior superior spines. In s... ... below the level of the ... ... (Fig. 83 (*b*)).

This rotation of the pelvis]may become so great in cases of extreme slip as to cause a peculiar change in posture. The hip joint rotates with the pelvis till the thigh, even in the extreme of full extension at the hip, fails to place itself vertically beneath the trunk. In consequence, if the man stands with his trunk erect, his hips remain slightly flexed and then his knees must also be flexed. If he stands with his legs straight his

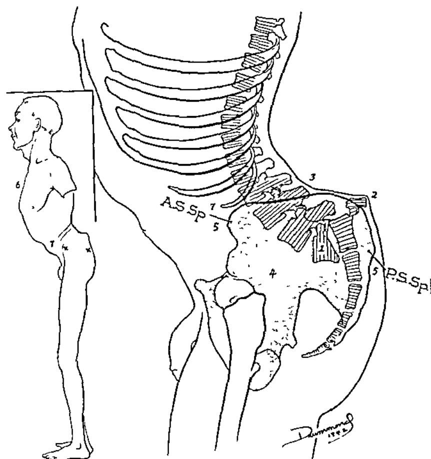


Fig. 84. [illegible]

deformity is great the trunk cannot be held erect over the legs even when the hip joint is fully extended. (7) The trunk settles down into the pelvis, the lower ribs touch the iliac crest and folds appear about the waist.

trunk must be tilted forward from the hips and the upper lumbar spine hyperextended for compensation.

When the forward slip is great, the trunk is shortened from above downwards, transverse folds appear about the waist and the lower ribs touch the iliac crests or disappear within the false pelvis. In extreme cases the deformity may be very great and very complex since the body of the fifth lumbar vertebra may have slipped completely off the top of the sacrum and lie with its inferior surface applied to the anterior face of the sacrum. The various elements in the deformity of spondylolisthesis are depicted in the diagram illustrated in Fig. 84.

DIAGNOSIS

With well-marked deformity the diagnosis of spondylolisthesis is simple. When the deformity is inconspicuous the diagnosis may not be easy. The items of greatest value in making a diagnosis are (1) the history of pain low in the lumbar region; (2) the addition of sciatica to the lumbar pain: if this is bilateral it is particularly significant and in severe cases peroneal palsy adds to the significance; (3) the deformity if it is present and (4) the radiographic findings. The forward displacement of the body of the involved vertebra can be recognized with certainty only in a good lateral radiograph. As a rule this projection shows also the defect in the neural arch (Fig. 77). If the gap at the defect is slight and there is no forward displacement of the body of the involved vertebra, oblique radiographic projections are valuable to demonstrate the lesion since only by this means can the x-ray be projected through the defect to reveal its presence (Fig. 78). Oblique laminograms are particularly valuable.

TREATMENT

The basic principle of treatment is stabilization of the involved vertebra. This fixation may be secured by the external application of a spinal brace or corset; or by the much more efficient internal fixation of lumbo-sacral fusion. Nice judgment is necessary to determine the treatment best suited to the individual patient. Some have few symptoms and are so little disabled that it is hardly justifiable to subject them to the risk and inconvenience of operation. Others have severe and progressive symptoms which will not be adequately relieved except by operation. There is an intermediate group whose disability is moderately severe, but by the use of a brace and great restriction of activity, they can manage to live a life of some usefulness. Operation for them is not essential though a successful lumbo-sacral fusion would relieve them of all symptoms and restore them to a life of unrestricted activity.

The factors which must be taken into consideration in determining whether treatment shall be conservative or operative are (1) the degree of disablement; (2) whether or not the symptoms and deformity are progressive and (3) the age of the patient. If the disability is severe and progressive, the argument is strong for operative fusion. Age is an important factor. As a general rule the younger patients should be operated upon even though their symptoms are not severe. Solid fusion can usually be anticipated and by this they can be spared a lifetime of invalidism. In older patients operation should be undertaken more cautiously. Fusion is less easily secured. The risk is somewhat greater. The time which must be expended in post-operative fixation imposes a greater economic burden. It may be possible to adjust conditions of living so that less stress is placed upon the unstable vertebra and this, with a brace, may be all that is necessary.

Operative treatment of spondylolisthesis

The most effective treatment of spondylolisthesis is lumbo-sacral fusion. If the lower lumbar spine is successfully fused to the sacrum, bridging the defective vertebra with an adequate mass of bone, the patient's symptoms disappear, his back is strong again and he is capable of hard work. Posterior fusion, which bridges together the spines and laminae, is best since it permits greater flexibility of technique to meet special difficulties, provides a solid mass of bone and does not involve as great a risk as does the anterior body-to-body fusion through a transperitoneal approach.

Operation, however, is not to be undertaken lightly. The procedure is prolonged and is associated with some risk to the patient from haemorrhage and shock, and occasionally from infection, and complications can mar the result even when fusion has been secured. The operation is the most difficult of all spinal fusions and demands

the utmost in technical skill from the surgeon. Nothing short of perfect fusion will meet the needs of the patient and this is by no means easy to attain. It is less likely to succeed after middle life than in youth. At any age the operation must be planned and executed with precise regard to the fundamental principles of bone transplantation and with meticulous regard to technique.

There is no single perfect operative technique applicable to all cases. The anatomical circumstances vary from case to case and in a manner which precludes rigid standardization. There are, however, certain basic essentials which must be achieved. (*a*) The fusion must be massive since the whole weight of the body will be transmitted through it together with all the stresses of movement and effort. (*b*) The anchorage to the sacrum must be large, secure and quickly attained. (*c*) Anchorage to the vertebrae above the lesion must be equally secure and broad, yet if possible it must be limited to the one vertebra immediately above the lesion. To extend it farther accumulates stresses upon the graft and also upon the point of mobility immediately above the graft. These stresses may cause fracture of the graft or failure of fusion, or arthritic changes due to sharply localized movement at the junction of the fixed and mobile segments of the spine (*d*) The technique of fusion should permit such firm fixation of the grafts to the sacrum and to the lumbar spine as will assure a degree of internal splinting during the post-operative period capable of resisting the movement in the lumbo-sacral region which cannot be completely obliterated by any kind of external fixation. (*e*) There must be sufficient post-operative protection of the graft from stress and movement to ensure fusion and avoid fracture of the graft. This necessitates adequate recumbency (4 months) in the immediate post-operative period and protection by a brace for the first 6 months of ambulation. Though it would be desirable to reduce the prolonged period of post-operative recumbency, it is futile to expect satisfactory fusion without an adequate period of post-operative fixation. To shorten this period risks the price of too high a proportion of failures of union. (*f*) The resumption of strenuous activity must be gradual to avoid the danger of too great stress too soon upon the graft before it has time to become completely reorganized into living bone.

These requirements are best met by the use of tibial grafts supplemented with cancellous bone from the upper end of the tibia or from the wing of the ilium. The tibial grafts give strength in the immediate post-operative period and lend themselves well to firm fixation to the sacrum and to the lumbar spinous processes. The addition of cancellous bone ensures the early development of new bone which ultimately will become a massive bridge of fusion. Cancellous bone alone or multiple fragment grafts do not give the fixation necessary to form a solid bridge. Too frequently such fusions end in pseudarthrosis.

A satisfactory technique for lumbo-sacral fusion for spondylolisthesis is illustrated and described in Figs. 85–89. Fig. 90 shows the successful result of the operative treatment described.

During the post-operative period the field of operation must be kept as completely still as possible, and this must be accomplished in a manner which will permit daily turning of the patient to prevent nephrolithiasis. A bivalved double plaster spica is effective. The Stryker turning frame is also effective and has the additional advantages of simplicity and convenience.

Operative correction of the vertebral displacement

An important accessory problem which may require operative management is restoration of the displaced vertebral body to its normal position. If the amount of slip is small, the deformity is of little significance. But when the displacement is great, it becomes of itself a cause of disability, even after the spine has been stabilized by fusion.

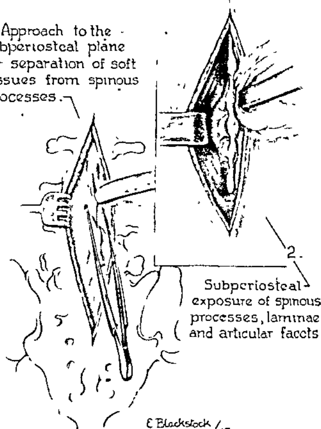


FIG. 85.—Technique of the operation for spondylolisthesis. The soft tissues are elevated from the spines and laminae by separation in the subperiosteal plane. *Step* 1—The fibrous tissue attached to the tip of the spine is split to the bone and separation in the subperiosteal plane is commenced with a Bristow raspatory. *Step* 2—Once the subperiosteal plane is entered the muscles are wiped off by forceful packing with gauze.

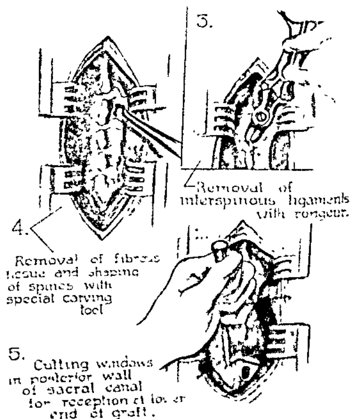


FIG. 86.—Preparation of the field for the bone graft *Step* 3—Upper half of interspinous ligaments is removed with a rongeur baring the bone of the spinous processes. This provides a space into which cancellous bone will be packed. *Step* 4—The spines and laminae are carefully denuded of all soft tissue, using special carving tools. *Step* 5—Windows are cut in the posterior wall of the sacral canal for the reception of the lower end of the tibial grafts.

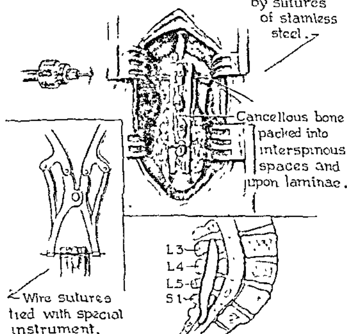


FIG 87.—*Step* 6—The lower ends of the tibial grafts after suitable modelling are inserted into the windows in the sacral canal The upper end of the graft is then accurately applied to the spinous processes and laminae of lumbar vertebrae 3, 4 and 5 Cancellous bone is packed into the interspinous spaces and on to the denuded laminae. The tibial grafts are fastened securely in position by two sutures of s w g 20 stainless steel wire tied in a square knot with a special tying instrument.

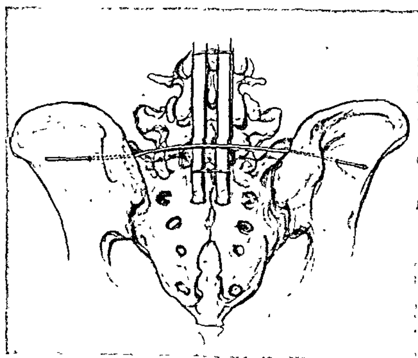


FIG. 88.—In certain cases for additional security the lower ends of the grafts are held pressed against the sacrum by a heavy Kirschner wire passed through the wings of the ilii and arched over the grafts. This wire is removed after four months.

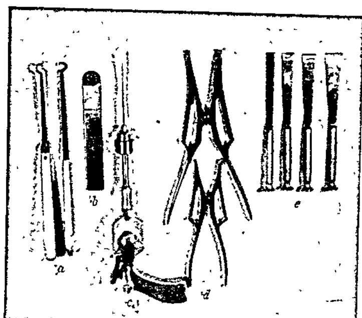


Fig. 89.—Certain instruments of special design useful in operation for spondylolisthesis. (*a*) Curved scrapers modelled after the tools for "drawing out" the core of a wooden leg Useful for cleaning the laminae and spines and carving them to shape. (*b*) Round-ended Swedish osteotome for quick scraping of soft tissues from base of spines and laminae. (*c*) Drill with eyed Kirschner wire by means of which the stainless steel wire suture is placed through the grafts and spinous processes. (*d*) Instruments to tie the knots in the stainless steel wire suture. (*e*) Thin osteotomes of various widths.



Fig. 90.—Lateral radiograph to show the successful result obtained by the operation described above. The massive bridge of bone extends from the sacrum to the spine of the third lumbar vertebra. Fig. 77 is the pre-operative radiograph of this patient.

Correction of the deformity to something approaching its normal relationship to the sacrum is less difficult than might be supposed. A method which has been found effective is illustrated in Figs. 91 and 92, and the result which can be obtained is illustrated in Figs. 93 and 94.

Results of operative treatment of spondylolisthesis

Generally speaking it can be stated that the operative treatment of spondylolisthesis cures the patient of his symptoms *if* solid fusion is obtained. But the "if" is a big one. The technical problems involved in planning and executing the right type of operation, in ensuring solid placement of the grafts, in maintaining stillness in the field of operation till fusion has occurred and in protecting the graft from undue stress until it acquires its maximum strength are so numerous, so complex and so vital that some technical failures may occasionally occur. If solid fusion is obtained by operation, the improvement is dramatic. Usually it amounts to restoration of normal function.

Unsatisfactory results

The most frequent cause of an unsatisfactory result from operation for spondylolisthesis is failure to obtain fusion of the lumbo-sacral region. This can be the result of failure of the grafts to unite to the sacrum or to the spinous processes of the lumbar vertebrae; imperfect fixation of the grafts to their bed so that contact is poor; undue movement of the grafts in their bed; a small and inadequate bridge of bone; fracture of the graft with subsequent non-union at the site of the fracture. Most such failures can be attributed to technical imperfections in the operation capable of elimination by improved operative technique arising from increased experience.

A small group of patients have disability despite solid fusion because of the persistence of a major degree of deformity.

Potential complications

Those complications which may mar the operative result are haemorrhage and shock, infection, thrombophlebitis, stress fracture of the tibia from which the graft has been taken and nephrolithiasis due to recumbency.

Haemorrhage and shock can be guarded against during the operation and can be corrected by appropriate measures.

Infection today is fortunately an almost non-existent problem. Improved operative technique and the antibiotic agents have virtually eliminated this complication. There is great merit in the local use of antibiotic agents for prophylaxis against infection in this as in all operations of great magnitude upon bone.

Thrombophlebitis is an ever-present danger. Since it almost invariably develops in the leg from which the bone graft has been removed, one cannot escape the conclusion that the trauma of this procedure and the subsequent confinement of the limb in a dressing are the major factors in initiating thrombophlebitis. The risk of pulmonary embolus is real if small and the potential late disability from disturbance of the circulation in the leg mars the perfection of the result. Every precaution should be taken to prevent the development of thrombophlebitis by minimum trauma to the lower extremities, by the avoidance of tight dressing and by daily active movement [illegible]

but is seldom recognized. The patient who complains of persistent soreness in the shin after he commences to walk and who has localized tenderness at the same point, perhaps with a small firm tender swelling of the bone, almost certainly has a stress fracture. Tangential radiographs will reveal the characteristic deposit of subperiosteal new bone and the transverse hairline break in the tibial cortex. Fortunately the

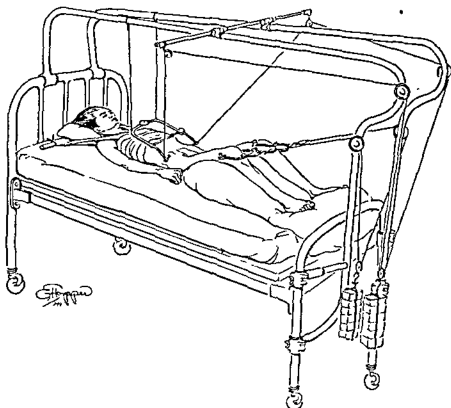


FIG. 91.—Line drawing to illustrate the method of [illegible]

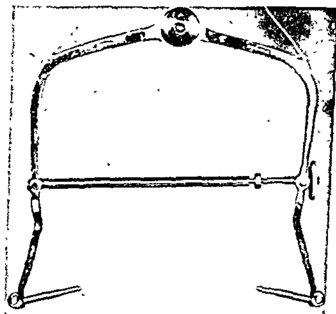


FIG. 92.—The ice tongs used to apply skeletal traction to the pelvis to lift it forward.



Fig. 93.—Correction of the displacement in spondylolisthesis. This was the state before operation and shows the body of the fifth lumbar vertebra displaced completely from the top of the sacrum and lying on the anterior face of the sacrum in front of the interspace between the first and second sacral segments. It has rotated about a transverse axis through 90° so that its inferior surface is applied to the anterior surface of the sacrum.



Fig. 94.—The correction obtained by skeletal traction applied after the method illustrated in Fig. 91. The body of the fifth lumbar vertebra has now been replaced on to the superior surface of the sacrum.

disability from stress fracture of the tibia is not great and the outcome is always satisfactory.

Nephrolithiasis may develop in the post-operative period of the treatment of spondylolisthesis as it may in any condition which involves prolonged and unremitting recumbency, especially in the supine position. It can be prevented almost entirely by daily turning of the patient. For this purpose the Stryker turning frame is particularly valuable since it permits easy turning of the patient without disturbance of the field of operation.

(*See also British Surgical Practice:* Spinal Column, Vol. 7, page 539, S. Key 306.)

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TRACHEA, HYPOPHARYNX AND CERVICAL OESOPHAGUS—RECONSTRUCTION

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A direct anastomosis that heals by first intention is unlikely to be surpassed as a method of uniting the hollow viscera. Reconstruction of either the trachea or cervical oesophagus presents special problems because a primary end-to-end anastomosis is rarely possible.

THE TRACHEA

Anatomy

The average length of the adult human trachea is 10·5 centimetres from the lower part of the larynx to its bifurcation into the right and left main bronchi. The trachea is semi-mobile, its bifurcation can be raised about 2·5 centimetres by swallowing or deep respiration. In the child it is relatively more mobile than in the adult. It also possesses some longitudinal elasticity but this decreases rapidly during the fourth and fifth decades of life. The importance of this is that an end-to-end anastomosis is unlikely to succeed if more than 2 centimetres are removed; beyond this tension would be too great; a fact which has been confirmed during operations and the dissection of fresh human cadavers.

The left main bronchus is nearly 5 centimetres long, the right is almost non-existent because of its early division into the upper lobe bronchus and the stem bronchus leading to the middle and lower lobes; a difference which is of importance when their reconstruction is under consideration.

The trachea and main bronchi consist of a framework of cartilaginous rings united by fibrous tissue, elastic tissue and unstriped muscle, the lining is columnar ciliated epithelium resting on a well-marked basement membrane. This structure prevents their walls falling together and any extensive repair must possess similar rigidity.

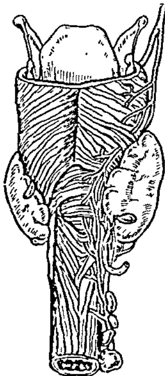


Fig 95.—The relationship of the laryngeal nerves to the back of the pharynx, oesophagus and thyroid gland.

The recurrent laryngeal and superior laryngeal nerves are vital when a reconstruction operation is to be performed. Bilateral recurrent laryngeal nerve palsy prevents tracheal reconstruction by obstructing the airway, and paralysis of both superior laryngeal nerves anaesthetizes the entrance to the larynx so that the patient may inhale food into the remade trachea with fatal results (Fig. 95). At the moment, reconstruction of the trachea is only possible if at least one recurrent laryngeal and one superior laryngeal nerve can be preserved. Both superior laryngeal

nerves may be divided if there is an interval of a few weeks between the operations; presumably the glossopharyngeal nerve takes over some of the sensory area.

The lymphatic drainage from the trachea is to the paratracheal glands and then to the deep cervical chain on both sides of the neck or lower down to the mediastinal glands. Removal of these glands is an important step in the excision of a primary carcinoma of the trachea, a possibility in the neck, but difficult within the thorax because the metastases are likely to be bilateral.

Experimental surgery

Resection and primary suture of the trachea has been the subject of research, particularly at the Mayo Clinic. Clagett, Grindlay and Moersch (1948) reported that the trachea of a dog possesses great elasticity and that end-to-end anastomosis was possible after the resection of a quarter of its length. In addition they have resected the bifurcation of the trachea and repaired the defect by anastomosing the left main bronchus to the trachea. In this operation the right lung was removed together with the lower thoracic trachea, its bifurcation and a portion of the left main bronchus. To facilitate the anastomosis a tuck was taken posteriorly in the membrane of the trachea so that its lumen approximated to that of the left main bronchus.

The gap which remains after resection of the trachea may be closed in a variety of ways. The experience of others with the closure of tracheal fistulae is of help. In 1896 Koenig successfully closed a fistula by a two-stage operation. At the first stage he grafted a small piece of rib into the subcutaneous tissues of the neck; 6 weeks later a skin flap containing this piece of bone was turned across the fistula. In 1911 Hohmeier, as the result of animal experiments, showed that a small defect in the tracheal wall, 0·75 centimetre square, could be closed with a free graft of fascia lata. This work has been repeated, and Neuhof in 1917 found that a patch of fascia lata placed over a window in a dog's trachea, 0·25 centimetre square, was completely covered by columnar ciliated epithelium in 6 weeks. In 1912 Levit and a year later Lucas used a free graft of fascia lata to close a long-standing tracheal fistula in a patient; both operations were successful. More recently Daniel (1948) repeated this work with fascia lata: in addition he used fibrin film and the connective tissues of the neck to cover small tracheal windows in dogs. Negus (1950) has closed a traumatic fistula between the trachea and oesophagus by interposing the divided sternomastoid muscle.

The defect in the trachea may be total or it may be possible to leave a narrow bridge of epithelium between the ends; a bridge of this sort will assist healing to a great extent. The closure of any large defect in the trachea requires special treatment because the material which bridges the gap must possess sufficient rigidity to withstand the pressures of respiration. If a flaccid wall is provided it will be drawn into the tracheal lumen during inspiration and produce respiratory obstruction; in addition the closure must be airtight or nearly so. Mediastinitis, which might be expected to kill these patients, appears to be an uncommon complication in both man and experimental animals. This is due to modern antibiotic drugs and the fact that the tissues of the neck and mediastinum rapidly seal off the operation site, provided that severe surgical emphysema does not develop during the first few hours.

Two types of tube have been used; first, a complete cylinder of polythene or
... fascia lata to make it air-
... logs and replaced it with a
... th greater success because
polythene is unwettable and mucus does not adhere to it. When vitallium was used the tube became so coated with mucus that tracheal obstruction and death frequently followed. In Grindlay's dogs the polythene tube was surrounded by an intact layer of epithelium but this epithelium was outside the polythene, therefore he removed the

tube from several dogs after an interval had elapsed for this layer of epithelium to form. Unfortunately the tracheal wall was not rigid enough and better results were obtained when the tube remained in position. I understand that 6 dogs operated on by Grindlay have lived 3 or more years after such a polythene anastomosis and all are fit and well.

The other type of tube consisting of a fine tantalum wire mesh (tantalum gauze), or a spiral wire coil, as used by Belsey, has been the subject of investigation at St. Thomas's Hospital. Portions of the cervical trachea, up to 90 per cent of the

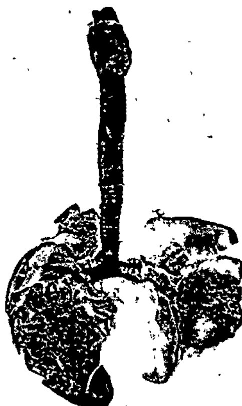


FIG 96—The trachea of a rabbit one month after a defect 1 centimetre long and occupying 90 per cent of its circumference had been repaired with a patch of fascia lata and tantalum gauze

circumference and 1·5 centimetres in lengths, have been resected from 12 rabbits and the defects closed with tantalum gauze covered by fascia lata, which has been sutured to the trachea with interrupted silk (Fig. 96). Resection of a complete segment of the trachea has not been performed because the necessary permission could not be obtained. This method of reconstruction has proved satisfactory, and the seal has been airtight. One rabbit died from an abscess in the neck but the rest survived without any demonstrable abnormality until they were killed.

This investigation—besides showing that the method works—has given some information of general interest. First, the tantalum gauze is inert in the tissues which accept it with little reaction. Secondly, it is sufficiently strong to withstand the pressures of respiration and movements of the neck. Thirdly, the epithelium grows on the inside

of the tantalum gauze so that a lining of columnar ciliated epithelium covers the defect. This is the opposite to the state of affairs after the insertion of a polythene tube. It appears that the reason why the epithelium grows on the inner side of such a tube but on the outer side of a polythene tube is because it is not an impervious cylinder but consists of a fine wire mesh. Granulation tissue is able to pass through this mesh and so a granulating layer is available on the inner side of the wire on which the tracheal epithelium can grow. Fourthly, the rate of epithelial growth appears to be much greater than Neuhof thought. In rabbits a defect 1 centimetre square is completely covered by columnar ciliated epithelium in 4 weeks, and as will be shown later, the rate of growth in man is even faster. Fifthly, the fascia lata does not survive; it merely provides a temporary seal until the tissue planes of the neck have become closed around the tantalum gauze.

Indications

Tracheostomy is by far the most common tracheal operation. According to Galen it was first performed by Asclepiades in the second century B.C. A permanent tracheal fistula may result, this coupled with scarring and stenosis is the most frequent indication for a reconstruction operation.

Wounds of the trachea both operative and traumatic are rare; with the latter an associated large vessel injury often proves fatal. When seen early the best treatment is excision of the wound and primary suture of the trachea; if there is loss of substance or fibrosis from an untreated wound reconstruction will be required later.

Benign tumours are an important reason for resecting and reconstructing the trachea. Many can be treated endoscopically but others should be excised. According to Ellman and Whittaker (1947), 253 simple tumours have been recorded in the literature: 75 of these were chondromas, 67 papillomas, 19 adenomas and the remainder of various types. If a benign tumour obstructs the lumen a partial resection of the tracheal wall is more likely to cure the patient than endoscopic removal which is unlikely to reach the whole growth.

Malignant tumours may be primary or secondary. In early cases the surgeon's aim will be to cure the patient, in the remainder considerable benefit will result if he can relieve the respiratory obstruction either with a tracheostomy or a palliative resection and reconstruction operation. The primary tumour is rare, 187 carcinomas had been reported by 1945 (Ellman and Whittaker). The following types occur: adenocarcinoma (47 per cent), squamous-cell carcinoma (41 per cent), or a basal-cell carcinoma (12 per cent); 50 per cent of these are in the lower third of the trachea, 35 per cent in the upper third and 15 per cent in the middle third. Adenocarcinomas and basal-cell tumours have a better prognosis than the squamous-cell variety. the last-mentioned will rarely be operable by the time the surgeon sees it. None the less, favourable results may be obtained by resection of the trachea as illustrated by the 7 patients Olsen (1939) [illegible] after resection was not performed in any [illegible] npairment and [illegible] constant menace of [illegible] results which make such radical surgical treatment undesirable. These unpleasant sequelae can be removed by an efficient reconstruction operation.

Secondary malignant invasion of the trachea is relatively common. A few such patients, particularly those with highly differentiated thyroid carcinomas, may be suitable for removal of part of the trachea in addition to the primary tumour.

Anaesthesia

A patient with a tracheal tumour tests the art of the anaesthetist to the full. By the time the patient has come to operation there may be a considerable degree of obstruction. For lesions of the upper two-thirds of the trachea the following method has

been found satisfactory. Under local surface anaesthesia of the mouth, pharynx, larynx and trachea a long, cuffed endotracheal tube is passed down the trachea right through the growth. The cuff is inflated and thus seals off the lower trachea, bronchi and lungs from the operation site. At this stage a quantity of sputum which may have been imprisoned below the constricting growth is coughed up or sucked out, after which the respiratory efficiency of the patient improves. When the bronchial tree is clear a general anaesthesia can be given. Sometimes the sucker must be passed before the endotracheal tube can be inserted but this must be done with gentleness because the surface of the growth is likely to bleed and block the airway.

When the lesion is in the lower trachea or larger bronchi the same method can be used but the cuff lies at the level of the tumour. The trachea can be removed from around the cuff and then rebuilt over it, but as the operation site is not shut off from the bronchi and lungs, care must be taken to keep them clear. Both the surgeon—by minimizing spillage—and the anaesthetist—by intermittent suction—can help to achieve this. If the air leak around the cuff is too great or if the tumour involves one main bronchus a one-lung anaesthetic is necessary with the tube passed into the appropriate bronchus.

The operation

Excision for carcinoma

The first essential is to excise the primary tumour with its lymphatic field of drainage, an ideal which cannot be achieved in every case. The trachea may be approached from the neck, from the thorax or by a combined thoraco-cervical incision. In my opinion the thoraco-cervical incision is unsatisfactory because the thoracic portion of the trachea is not easily accessible and a better exposure is achieved by using separate cervical and thoracic incisions simultaneously if necessary.

The cervical approach.—A long collar incision with vertical extensions upwards and downwards over the substance of each sternomastoid muscle will give adequate exposure of the cervical trachea and its lymphatic drainage into the paratracheal and deep cervical lymph glands. After the skin flaps have been raised the infrahyoid muscles are divided and the thyroid gland exposed. The next step is to divide on both sides the middle and inferior thyroid veins and the inferior thyroid arteries. This enables the surgeon to lift up the thyroid gland, after which he can palpate the trachea and assess the operability of the tumour. When operable, the next and a most essential step is the isolation and preservation of at least one, and preferably both, recurrent laryngeal nerves. After this the trachea is separated from the oesophagus and the dissection carried down into the mediastinum. If it is impossible to get at least 1 centimetre below the growth the patient is placed on his left side and the thorax opened on the right side, after which the dissection is continued down to the carina and main bronchi (*see* Thoracic approach). In the purely cervical operation the inferior deep cervical and paratracheal lymph glands are now freed and the trachea resected together with these glands and other structures, such as a portion of the thyroid gland, if these are involved by growth. At the conclusion of this stage the endotracheal tube should be seen lying across the gap in the trachea with the oeso- [illegible]

struction impossible, because a method has yet to be devised by which both the trachea and oesophagus can be replaced simultaneously. In such a patient the oesphagus may be repaired and the patient given a tracheostomy. The surgeon should not puncture the cuff of the endotracheal tube when he is resecting the trachea. If he does it will be necessary to pass a fresh tube which will add to the risk of infection.

The thoracic approach.—A right thoracotomy is preferable to a left thoracotomy unless the growth has involved the left main bronchus. The reason is that the trachea is more easily reached from the right and, as Clagett, Grindlay and Moersch (1948) report, it may be possible to resect the right lung and anastomose the left bronchus to the trachea. This formidable procedure may be justified in an occasional patient but it is probably only possible when the longer left main bronchus can be used for the anastomosis.

A formal thoracotomy incision is made, the scapula retracted upwards and the fourth rib resected for at least 20 centimetres of its length. The pleura is opened and the ribs spread. After the lung has been partially collapsed it can be retracted downwards and the mediastinum inspected. Next, the main azygos vein is divided between ligatures and the trachea freed from the base of the neck to its bifurcation. After this the mediastinal lymph glands and vessels are removed over as wide an area as possible and the trachea resected. If the endotracheal tube becomes loose during this manoeuvre the cuff can be deflated, the tube inserted into the left main bronchus and the anaesthetic continued into one lung.

Reconstruction

According to Olsen (1939) the literature contains the reports of 7 successful resections of the trachea; all were left with a permanent tracheostomy and no attempt was made at reconstruction. Several of these patients lived for a number of years but in spite of this Olsen concludes that the operation of tracheal resection is unsatisfactory because of the permanent tracheostomy. Therefore an attempt should be made to improve on this by a reconstruction operation.

By suture.—In 1948 Griffith successfully sutured a ruptured left main bronchus. The accident had occurred 7 months before. At operation the scar tissue was resected and an end-to-end anastomosis performed with stainless-steel wire stitches: the suture line was reinforced with a free graft of fascia taken from the sheath of the erector spinae muscles (Griffith, 1949).

Wounds of the trachea have been sutured in both war and peace. On two occasions I have sutured a tracheal wound using interrupted silk stitches without any post-operative complications. Occasionally the defect after the excision of a malignant tumour is so small that primary suture is possible. Grimes and Bell (1948) record such a patient. An adenocarcinoma of the thyroid had invaded the posterior and left lateral [illegible] centimetres in diameter remained [illegible]. In addition, [illegible] by primary suture of [illegible] of the hole.

With a [illegible] animals has been [illegible] esected a cylindroma from the lower trachea—it had involved the right main bronchus; the lower trachea, its bifurcation and the right lung were resected. Reconstruction was carried out by uniting the trachea to the left main bronchus with a moulded polythene tube. After this formidable operation the patient was well for several days but the tube then moved and obstructed the airway with fatal results.

With fascia lata and stainless-steel wire.—Belsey (1946) used this method to reconstruct the trachea after he had removed nearly the whole of its intrathoracic portion from the sternal notch to the carina; only a narrow strip of the wall, a quarter of an inch wide, was retained on the left side. A spiral of 32-gauge stainless-steel wire 3 inches long was then sutured between the cut ends of the trachea and surrounded with a free graft of fascia lata; the graft was sutured into position with wire sutures. Convalescence was uneventful and the patient lived for 2½ years before the adenocarcinoma for which the resection had been performed recurred and she died.

With fascia lata and tantalum gauze.—I have used this method on three occasions: one was a primary squamous-cell carcinoma arising from the trachea at the level of the sternal notch, the second another squamous-cell carcinoma which was situated in the middle of the thoracic trachea, and the third was a carcinoma of the thyroid which had invaded the trachea. All three had received a full course of radiotherapy before they were referred for surgery. In each patient reconstruction was with a tube of tantalum gauze covered on both sides with fascia lata. The result was excellent in the third patient, fair in the first, and the second died 17 days after his operation.

The fatal case developed severe tracheal stenosis after radiotherapy; as a result a great deal of sputum collected in the bronchial tree behind this stricture. During the first 24 hours after reconstruction he coughed up 21 ounces of sputum but in spite of this his progress was satisfactory until the eighth day when the wound became infected. This appeared to be settling down and his airway was adequate until death occurred on the seventeenth day from secondary haemorrhage into the trachea; at post-mortem examination the bleeding vessels seemed to have been in the tracheal wall. The wound of the other primary tracheal carcinoma also became infected. This subsided after removal of the tantalum gauze through the cervical incision and his wound healed with a normal airway. This patient died 5 months later with metastases in the thoracic lymphatic glands, the brain and locally in the trachea, but his airway was adequate to the end and he died in coma from the cerebral secondaries

The third patient is alive and well 2½ years after his operation. A thyroid carcinoma of low malignancy had invaded the trachea; it was radio-resistant. Endoscopy showed a haemorrhagic mass on the anterior tracheal wall just below the glottis but no detail could be determined because of the bleeding. In August 1948 the tumour was resected. This necessitated the removal of a portion of the cricoid cartilage and six tracheal rings (Fig 97). It was found possible to preserve a narrow strip of epithelium on the posterior wall less than 0 5 centimetre wide, both recurrent laryngeal nerves, and at least one parathyroid gland. A primary closure was carried out with the aid of a tube of tantalum gauze covered on both sides by fascia lata (Fig. 98). This was sewn to the trachea with interrupted silk sutures.

During the first post-operative day the patient breathed satisfactorily, was able to cough up his sputum, spoke well, and had no difficulty with swallowing. On the second day he developed an atelectasis of the lower lobe of the right lung and at the same time found coughing difficult. Bronchial aspiration was therefore performed 3 times during the next 36 hours. On the third occasion a bronchoscope was passed down the trachea right through the graft · the fascia was healthy in appearance but the inner layer was seen to be drawn into the trachea with each inspiration, producing a partial obstruction. On the sixteenth post-operative day a further bronchoscopy showed that the inner layer of fascia was still partially occluding the lumen: it was therefore destroyed with a diathermy electrode. Fig. 99 is a radiograph showing the position of the tantalum gauze in his neck.

He was discharged from hospital 7 weeks after his operation and returned to work 3 weeks later. It is now 2½ years since he left hospital and he has no symptoms or signs of recurrence. Eighteen months after this operation he perforated a duodenal ulcer; the anaesthetist passed a bronchoscope and reported that his trachea was of normal appearance. He had no post-operative pulmonary complications.

Results and conclusions

Plastic operations to relieve stenosis or to close fistulae have been performed many times, but the repair of a large gap in the trachea is a rare operation. All the cases of which I can find published [illegible]
in [illegible]
the [illegible]



FIG. 97.—Operation specimen. Invasion of the trachea by thyroid carcinoma. The tissue removed includes *a portion of the cricoid* cartilage and 6 tracheal rings. (*By courtesy of Brit. J. Surg.*)

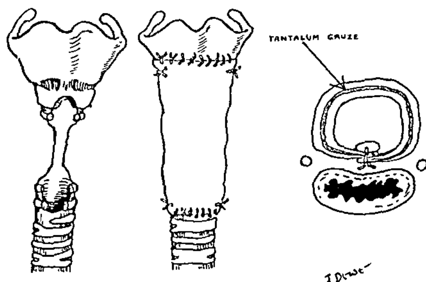


FIG. 98.—Reconstruction of the cervical trachea with fascia lata and tantalum gauze (*By courtesy of Brit. J Surg*)

airway, but the other 3 were not benefited. In spite of this, resection and reconstruction is the only treatment likely to cure a malignant tumour of the trachea; the alternative methods of radiotherapy or endoscopic removal are at the best palliative. I know of only one long-term survival following such treatment—in 1932 Negus inserted radium needles into an adenocarcinoma of the trachea and the patient survived for 17 years before he died of a recurrence.

The trachea and bronchi have a special structure to prevent their walls falling together; any extensive repair must possess similar rigidity. Polythene, stainless-steel wire, and tantalum gauze have been used to provide rigidity; which is the best has yet



FIG. 99 —Radiograph of the neck taken 1 year after tracheal reconstruction. The tantalum gauze is shown (*By courtesy of Brit J. Surg*)

to be decided. Polythene has yet to be used successfully in man, but it is very satisfactory in experimental animals. On the other hand, tantalum gauze allows the tracheal epithelium to grow across the gap so that a normal living membrane is restored.

THE HYPOPHARYNX AND CERVICAL OESOPHAGUS

Anatomy

The hypopharynx or laryngopharynx is that part of the pharynx situated below the level of the laryngeal aperture. Its anterior wall presents from above downwards the posterior surfaces of the arytenoid cartilages, the aryepiglottic folds, the piriform fossae and the posterior aspect of the cricoid cartilages; laterally lies the carotid sheath and, behind, the vertebral column.

The hypopharynx ends and the oesophagus begins at the cricopharyngeal sphincter, which is situated at the level of the lower border of the cricoid cartilage. The distance from the incisor teeth to the commencement of the oesophagus is about 15 centimetres in men and slightly less in women. It is a further 5 centimetres to the level of the sternal notch, where the cervical portion of the oesophagus ends and the thoracic oesophagus begins. In this article the reconstruction of the pharynx and oesophagus from the level of the laryngeal aperture to the sternal notch will be discussed.

The important relations of this part of the gullet are the trachea and larynx, the carotid sheath, the thyroid gland and the laryngeal nerves. As with the trachea, if reconstruction is to be successful at least one superior and one recurrent laryngeal nerve must be preserved; an exception to this rule can be made if a laryngectomy has to be performed.

The lymphatic drainage of the hypopharynx and cervical oesophagus is, *first*, to the numerous sub-epithelial lymph nodes which are present in this part of the alimentary tract, next, to the retropharyngeal and paratracheal glands and then to the deep cervical lymph glands.

The hypopharynx and cervical oesophagus have, *like the trachea, little* vertical mobility. From dissections of fresh human cadavers it appears that end-to-end anastomosis is unlikely to succeed if more than 3 centimetres are removed; beyond this tension would be too great unless the stomach and whole gullet were mobilized.

Indications

The principal indication for reconstructing the hypopharynx and cervical oesophagus is after the excision of a malignant tumour; a benign stricture is an uncommon secondary indication. The majority of the malignant tumours are squamous-cell epitheliomas, probably 95 per cent; the remainder are lympho-epitheliomas which are rare in the hypopharynx and almost unknown in the oesophagus.

Many of these tumours are of slow growth. According to Wookey (1948), of 70 patients who died from this disease at the Toronto General Hospital, 22 per cent had no metastases and in 16 per cent the regional lymph glands alone were involved at death. This is evidence that with a reasonably early diagnosis there is a good chance that the disease will be a purely local problem. Negus and others consider that many of these carcinomas arise in an area of chronic hypopharyngitis, often but not necessarily associated with anaemia in all such patients the first suspicion of malignant change is a strong indication for excision.

The only alterna ... This offers little chance of cure to the patie ... not one survived 3 ...

At St. Thomas's Hospital 492 patients were treated for carcinoma of the oesophagus and lower pharynx between 1923 and 1948, 101 of these growths were situated in the hypopharynx or cervical oesophagus. The treatment these 101 patients received, and the length of time they lived after their first attendance at hospital is shown in the following Table.

TABLE

CARCINOMA OF THE HYPOPHARYNX AND CERVICAL OESOPHAGUS. TREATMENT AND AVERAGE LENGTH OF SURVIVAL.

Treatment	*Number of patients*	*Average length of survival in months*
Palliative (no active measures)	30	2
Gastrostomy	27	3·75
Souttar's tube	3	4·75
Radiotherapy (+ gastrostomy in 6)	31	6·1
Excision	4	14·5
Records incomplete	6	—

The longest survival was 4 years and 1 month after an excision which was not followed by reconstruction. The longest survival after radiotherapy was 1 year and 6 months.

A review of the literature reveals several long-term survivals after surgical excision, including: Graham (1942) 2 patients, 15 and 23 years respectively; Trotter (quoted by Pilcher, 1937) 1 patient, 10 years; Evans (1933) 1 patient, 23 years; Colledge (1945) 3 patients, 8, 9 and 12 years; and Owen (1950) 2 patients for more than 5 years. On the other hand *I can find the records* of only 3 patients who survived for more than 5

years after radiotherapy; they are: Nielsen (1940) 1 patient, 6 years; and Watson and Pool (1948) 2 patients, both for more than 10 years.

Historical

The first resection of the upper oesophagus was performed in 1877 by Czerny. He removed 6 centimetres of oesophagus through a cervical incision but did not attempt reconstruction. This patient died after 15 months from a recurrence in the neck. In 1886 Mikulicz performed the first successful reconstruction of the cervical oesophagus. After removal of a carcinoma he used a skin flap to join the pharynx to the oesophageal stump. This three-stage operation was successful and the patient swallowed well until he died of his carcinoma 16 months later.

By 1899 de Quervain was able to collect from the literature the records of 14 resections of the cervical oesophagus for carcinoma: there were 5 operation deaths and all of the remainder died eventually of a recurrence. The extent of the operation was increased by von Hacker who, in 1908, reported the first successful resection of the hypopharynx and cervical oesophagus, together with the larynx and upper trachea: this patient was alive without a recurrence 16 months later.

Trotter perfected the skin-flap reconstruction operation In 1913 he reported in a Hunterian lecture the first 5 patients on whom he had completed the reconstruction after the removal of carcinomas. Since then many authors—notably Graham, Colledge and Wookey—have recorded their experiences with this type of reconstruction

Experimental surgery

Few surgeons have published experimental findings in this field. Sauerbruch, in 1905, reported the results of experiments on dogs. He resected portions of both the cervical and the thoracic oesophagus, then he restored continuity with an end-to-end anastomosis. The results were not encouraging and he attributed the failures to the following causes. undue tension, necrosis after excessive mobilization, and lack of firm tissue to grasp the sutures.

At St. Thomas's Hospital 2–3 centimentres of the cervical oesophagus has been removed from 7 rabbits, and a polythene tube inserted across the defect. A rabbit's diet of bran and vegetables tends to block such a tube—4 died within a week from this cause, but the remaining 3 survived. The mucosa grew across the defect outside the polythene tube which eventually became loose and was passed into the stomach. Fig 100 illustrates such an oesophagus removed 2 months after the operation, with a normal specimen for comparison. These experiments show that the rabbit's oesophagus will heal rapidly round a polythene tube and that serious infection occurs only if the tube becomes blocked by food. Even so, in the rabbit mediastinitis does not occur, inflammation being confined to the neck. It has not been possible to do experiments upon the fate of skin grafts wrapped round such a tube.

The operation

Excision

This must be a radical operation for the cure of cancer, and not a local removal. Trotter's lateral pharyngotomy excision and skin flap reconstruction is suitable only if the excised portion is small and entirely above the sternal notch. Wookey's modification of this operation with a larger skin flap and wider removal is an improvement, but again the size of the flap limits the area of possible reconstruction.

A collar incision across the neck at the level of the crico-thyroid membrane, combined with vertical extensions parallel to the sternomastoid muscle, allows the surgeon to remove the tumour in a more radical manner. If necessary he can remove the

hypopharynx, cervical oesophagus, larynx, part of the thyroid gland, and the d cervical lymph glands; but the resection need not be as extensive in every patient

Reconstruction

It is possible for a patient to maintain life for 20 years or more by feeding through oesophageal stoma at the base of the neck, but normal swallowing is essential happiness and every effort should be made to restore this as soon as possible.



FIG. 100 —Healing by second intention The rabbit's oesophagus on the right has been reconstructed by second intention healing around a polythene tube. The specimen on the left is from a normal rabbit.

By direct anastomosis.—For the anatomical reasons already given an end-to-end anastomosis has not been performed after an adequate resection of the hypopharynx and cervical oesophagus. A direct anastomosis may be possible if the stomach or small intestine is brought up into the neck. Sweet (1948) and Garlock (1948) have both anastomosed the stomach to the cervical oesophagus and it is possible that in the future a gastro-pharyngeal anastomosis may be performed, should a patient with favourable anatomical features require it. The disadvantages of such an operation are its magnitude and the temptation for the surgeon to conserve more than he should of the pharynx and upper oesophagus. This is probably the best method of reconstruction after the removal of the oesophagus between the sternal notch and the diaphragm. Theoretically after mobilization of the stomach and all the gullet an end-to-end anastomosis might be possible between the pharynx and the thoracic oesophagus, but this major procedure has yet to succeed in man and the blood supply of the oesophagus might well be insufficient. Fig. 101 illustrates three methods of reconstruction by direct anastomosis.

Skin flap operations—The principles of constructing a skin tube are shown in Fig. 102. After removal of the tumour either one large skin flap or preferably two smaller flaps are placed between the larynx and the vertebral column. This forms an open

groove in the neck between the oropharynx and the thoracic oesophagus. At a second operation this groove is converted into a complete tube, after which normal swallowing can be resumed. This operation is satisfactory for the treatment of small tumours entirely confined to the neck. Unfortunately, growths of the cervical oesophagus may be more extensive than the radiological or endoscopic findings indicate, and the skin flap method may then be insufficient to bridge the gap; in addition severe stenosis may develop as a late complication of an apparently successful reconstruction.

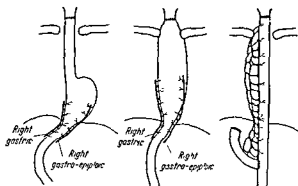
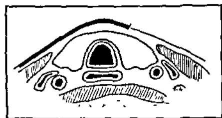
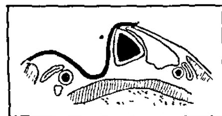


Fig 101 —Reconstruction by direct anastomosis. The first method is satisfactory in experimental animals but has yet to succeed in man, the second and third have been performed in man but all 3 are major procedures.

Satisfactory as this operation is, its limited field of usefulness is shown by the absence from the literature of any large series of results. Graham was able to perform it only 7 times before 1942, and few other surgeons can claim as large a series of completed cases.





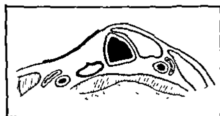


Fig 102 —Three diagrams illustrating the main principles of the skin flap reconstruction operation

Healing by second intention.—The mucosa of the pharynx and oesophagus proliferates at a remarkable rate. The simplest illustration of this is given by the raw area which remains after the repair of a cleft palate, this heals completely in about 2 weeks. Recently, this property of the mucous membrane has been used to reconstruct the hypopharynx and upper oesophagus. After resection the gap has been bridged by a splint of tantalum gauze covered by fascia lata The fascia provides a temporary seal to prevent infection of the neck, and the tantalum gauze, which is removed after about 2 months, provides a splint to maintain the lumen while the epithelium is growing across the defect. This method has been used by Bateman and myself (Rob and Bateman, 1949) on 3 occasions with fair success. An earlier attempt to use second intention healing in the reconstruction of the hypopharynx was that of Hoover, who in 1938 performed a local removal of a carcinoma on the posterior pharyngeal wall. A strip of epithelium 1 centimetre wide was left connecting the pharynx and oesophagus. A large rubber tube was passed across the defect and the cervical wound packed open; the patient was fed through the rubber tube and the neck wound had healed in one month. Four years later this patient had no recurrence, there was some tendency for stenosis to develop, and intermittent dilatation was necessary, but with this swallowing

was adequate. However, skin grafting is preferable to second intention healing and a split skin graft may be used with advantage instead of the fascia lata.

Primary repair by free skin grafting.—The advantages of this method over a skin-flap reconstruction are that a primary repair is possible and the surgeon is not limited by the size of the skin flap. It can be performed after a laryngopharyngectomy or the less radical pharyngectomy. This form of reconstruction has been carried out by

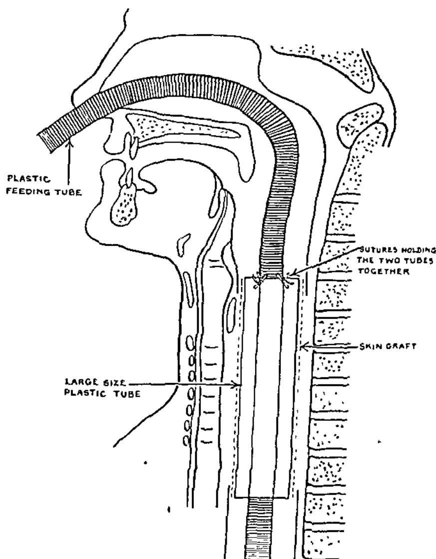


FIG. 103.—Primary repair using a free split skin graft and 2 plastic tubes.

Negus and myself on several occasions, but is still in an experimental phase requiring considerable improvement and modification before it can be recommended.

After removal of the growth a split-skin graft of suitable size is taken from the thigh. This is wrapped round a wide-bore polythene tube which is placed across the gap between the pharynx and the oesophagus. A second polythene tube of smaller size is now passed through the nose into the pharynx and down the centre of the first tube into the thoracic oesophagus (Fig. 103). The purpose of the outer and larger tube is to provide a splint to maintain the lumen whilst the skin graft and growing epithelium are covering the defect. The smaller inner tube is for feeding and to hold the outer tube in position. This latter function is important because the outer tube tends to pass

on into the stomach and a stitch of stainless-steel wire passed through the walls of the two tubes serves to prevent this by anchoring them together. After the tubes and skin graft have been fixed in position the wound is closed with drainage.

Post-operative care after primary repair with a free skin graft

A full course of penicillin and a sulphonamide is desirable, the drain may be removed after 2–3 days and the patient allowed to get up at about the same time. Feeding consists of a balanced high caloric fluid diet given down the nasal tube. This diet should be sufficient for the patient to gain the weight he had lost before the operation. Both tubes must remain in position until the defect in the gullet is completely covered by epithelium; even if the skin grafts take completely it is wise to leave these tubes in position for at least 2 months, and probably much longer because the longer they are left in position the less is the likelihood of a stricture. A polythene tube causes little irritation and even after 3 months the patient will be able to tolerate the nasal tube, and there will be little change in the epithelium of the nostril, a great advantage over a rubber tube which cannot be tolerated for long in the nose. Recently, Negus (1950) has designed a plastic tube with a funnel-shaped upper end and an expanded collar below; this tube should be unable to move either upwards or downwards, in which case it might be possible to do without the nasal feeding tube and allow the patient to go home with this plastic tube in position.

The patient's saliva trickles down between the two tubes, and some may discharge from the wound, but this discharge usually dries up and if the patient has not received a heavy dose of x-rays the skin wound should be healed by the tenth day. After 2–3 weeks the patient is allowed to drink fluids, which will pass down between the inner and the outer tubes; this serves to supplement the patient's diet, to wash the area and to restore confidence in the ultimate return of normal swallowing.

Two months after the operation the patient may be taken to the operating theatre and a direct pharyngoscopy performed under general anaesthesia if necessary. If the whole area appears to be covered by intact epithelium the tubes are removed: if there are unhealed areas removal is postponed. The tubes can be removed by lifting them both into the oropharynx, the larger outer tube is then gripped with forceps, the stitch which is holding them together is cut and the smaller tube drawn out through the nose, after which the larger tube can be removed through the mouth.

After this the patient is given a fluid diet for a day or two and then allowed to eat whatever he fancies. He must attend regularly for endoscopic examinations so that any tendency to stricture formation or recurrence can be diagnosed and treated.

Conclusions

Carcinoma of the hypopharynx and cervical oesophagus can be treated by radiotherapy or surgical excision Radiotherapy is rarely curative and many patients do not receive even temporary benefit. When possible the growth should be excised; in most patients this will mean a radical operation with removal of the larynx, hypopharynx, cervical oesophagus, part of the thyroid gland and the lymphatic glands from the lower half of the neck.

After the radical excision of a carcinoma end-to-end anastomosis has seldom been used as a method of reconstructing the hypopharynx and cervical oesophagus Both the stomach and the small intestine have been mobilized, brought into the neck and joined to the cervical oesophagus, but both a gastropharyngostomy and an anastomosis between the pharynx and the thoracic oesophagus have yet to be performed in man (Fig. 101)

The standard method of reconstructing this portion of the gullet is with a skin flap. Unfortunately this operation is not suitable for every patient and it cannot be performed in one stage A primary repair has obvious advantages. A method using free

split-skin grafts has been tried: it is simple, permits radical removal of the growth and has proved satisfactory in a very small number of patients. It has yet to be perfected and to stand the test of time.

(*See also British Surgical Practice*: Oesophagus, Vol. 6, page 314, S Key 247.)

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ARTERIAL SURGERY—PROGRESS IN

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ARTERIAL INJURIES AND THEIR EFFECTS

Concomitant vein ligation

In 1914 Sir George Makins first suggested that the accompanying vein should be tied if a main artery was occluded. There has been argument ever since as to the benefit of the procedure. The most recent work does not support it. Simeone and Rundle (1948) found that the maximum amount of work which could be done by the limb of a cat when its nerve supply was stimulated was less if the main vein was tied as well as the artery. Mason Brown (1948) considered that concomitant vein ligation in injuries had not proved of benefit in World War II. The experience of DeBakey and Simeone was similar (1946)

Cullen and his colleagues (1949) produced further experimental evidence. They repeated the experiments on rabbits of Brooks, Johnson and Kirtley (1934) in which the common and external iliac arteries were tied with or without the accompanying veins. Unlike Brooks and his colleagues, they found no difference in the amount of necrosis occurring in the limbs of the animals in the two groups. A further series of experiments was done in which radioactive sodium solution was injected into the gastrocnemius muscle of rabbits and the efficiency of the circulation judged by its rate of absorption. There was no difference in the absorption rate in the two groups.

It therefore seems best in dealing with arterial injuries to preserve the accompanying vein unless it is damaged beyond repair. To tie it will not help the circulation if the artery is occluded and, if arterial continuity is restored, may lead to the venous obstruction syndrome which Paterson Ross (1946) has described.

Time factor in arterial injuries

The duration of ischaemia likely to produce gangrene and loss of a limb has been studied in dogs by Miller and Welch (1949). A thigh transecting operation was devised similar to that used by Callow and Welch (1950) in studying methods of restoring continuity in arteries. In this operation unrelieved obstruction of the femoral artery produced gangrene in 100 per cent of cases. Fifty-seven animals were available for analysis. These had the femoral artery tied, and continuity was restored at varying times, they fell into three groups, according to the period of ischaemia.

Group 1: Ischaemia from 1 to 6 hours; 90 per cent limbs survived
Group 2: Ischaemia from 12 to 18 hours, 50 per cent limbs survived
Group 3. Ischaemia from 24 to 30 hours; 20 per cent limbs survived

Function in the surviving limbs in group 1 was good; in the other groups some degree of contracture was always present, severe in group 3, but often slight in group 2.

Muscle change after vascular injury

Bowden and Gutmann (1949) have studied the histological changes in the limb muscles of 16 patients with contracture following vascular injury. Biopsy specimens

were taken at times varying from 40 to 800 days after the injury. Histologically 3 groups could be distinguished: (1) massive necrosis of muscle; (2) massive interstitial fibrosis; and (3) mixed patches of necrosis and interstitial fibrosis. The first group followed severe arterial injury. The other two types of change followed vascular injuries varying from division of a main artery to compression of smaller vessels by oedema or slow bleeding within the confines of *fascial compartments* or *plaster casts*.

In a few cases there was evidence of muscle regeneration.

This series of cases shows once more that Volkmann's or similar muscle contractures can arise from a variety of causes which require different forms of treatment.

Traumatic arterial spasm

The exact causes and the best methods of relieving traumatic spasm of large arteries have been in dispute for some years. In particular the role played by vasomotor nerves in the production and maintenance of the spasm has been obscure. Success in relieving the condition has been claimed for measures such as sympathetic ganglionectomy or block, stripping of the adventitia, excision of part of the vessel, exposure to the air, application of hot saline solution and a variety of others. In many cases these measures have been found to be useless. The contradictions are explicable when it is remembered that the duration of spasm is variable, so that a spontaneous relaxation at an opportune time may give the appearance of therapeutic success.

A study was started, therefore, by Kinmonth, Simeone and Perlow (1949) of the factors influencing the diameter of large arteries under controlled experimental conditions. Reflex spasm was first examined. It was produced by the technique of Barnes and Trueta (1942) by applying a tourniquet for some hours to the animal's thigh. Shrinkage of the contralateral arterial tree occurred as the systemic blood pressure fell and took place even if the possible components of a nervous reflex arc had been eliminated by lumbar sympathectomy or complete denervation of a limb.

Further investigations showed that alterations in systemic blood pressure produced by various means such as stimulation of afferent nerves, drugs, or other methods produced parallel changes in arterial diameter. This was true of the proximal part of the femoral and larger vessels. No evidence of a vasoconstrictor nerve supply could be found in these vessels on electric stimulation either directly or through the sympathetic chain, although such stimulation produced marked constriction of smaller and more distal vessels.

Direct mechanical trauma easily produced arterial spasm. It appears that the condition depends on contraction of the smooth muscle fibres of the vessel wall and is unrelated to nervous intervention. Persistent traumatic arterial spasm should, therefore, be treated first by measures designed to maintain the systemic blood pressure at a normal level and secondly by the local application to the vessel of drugs causing relaxation of smooth muscle. Papaverine appears to be the most effective. Systemic administration of such drugs is found to be without effect in animals (Kinmonth, 1950) or in man (Learmonth, 1950). Arterial compression by haemorrhage or oedema formation in confined fascial compartments needs to be distinguished from spasm, but in either case *exploration may be necessary*.

SURGICAL PHYSIOLOGY OF ARTERIES

The physiological factors regulating the diameter of large arteries and their relation to traumatic spasm have been discussed in the section relating to arterial injury.

Barcroft and Walker (1949) have studied the return of tone in blood vessels of the upper limb after sympathectomy. The average post-operative flow in a group of patients with normal vessels was 46 millilitres per 100 cubic centimetres of hand per minute measured by venous occlusion plethysmography. After one week it had fallen

to one-quarter of this and after two weeks to one-eighth. A similar falling-off occurred in a group of patients with Raynaud's disease. The final rates of flow were little if at all higher than before operation. These changes were thought to be due to recovery of tone in the arteries, arteriovenous anastomoses, arterioles and capillaries. Rates of recovery of tone after ganglionectomy and pre-ganglionic section were the same.

Skin temperature changes were not closely related to the alterations in rates of blood flow. This was expected as they are known to be unreliable at high rates of flow and also because they are dependent on blood flow through the skin of the finger-tips whereas the flows measured here were those through the whole hand.

The more persistent effects of sympathectomy observed clinically might also be explained by alterations in the finger-tip circulation which are not detectable by this method of plethysmography.

Lynn and Barcroft (1950) have studied the circulation in the feet before and after lumbar ganglionectomy, using similar methods. Blood flow in the feet reached a maximum of about ten times the pre-operative flow in the first two days then dropped rapidly during the first week, finally reaching a level at about twice the pre-operative flow, which was found to be maintained at the end of 3 months. The initial peak was not so high in patients with peripheral arterial disease such as arteriosclerosis, but the final level of flow, about twice the pre-operative, was the same.

Sympathectomized feet never had as high initial flows as occurred in the hands. This was thought to be due to the fact that feet contain a higher proportion of avascular tissue than do hands.

Skin temperature readings rose during the first two days after operation and then remained permanently at the same level. This was interpreted as due to two things, first, the high rate of flow achieved immediately after operation is not indicated by these readings so there is no peak, and secondly they give information about the skin circulation rather than the foot as a whole. It is possible that the skin circulation remains at a high level while the deeper circulation diminishes.

These studies of Barcroft and his associates confirm quantitatively the clinical findings which have always suggested that sympathectomized feet maintain a better circulation than do sympathectomized hands They also direct attention to one of the inherent properties of vessels, namely tone, and this may in the future help in a better understanding of conditions such as Raynaud's disease.

ARTERIAL GRAFTS AND OTHER METHODS OF RESTORING PATENCY

It was shown almost 50 years ago that arterial grafts could be transferred from one animal to another and function successfully. Much of this early work was performed by Carrel (1907). Its application to human patients was prevented for many years by technical difficulties and interest in the problem declined Recently some of these obstacles have been overcome and a great deal of progress has been made in both experimental and clinical fields. Gross and his associates in Boston have been responsible for most of these new and remarkable advances.

Heterografts (portions of artery transplated into an animal of a different species) tried by Gross, Bill and Peirce (1949) proved unsuccessful. Arterial autografts, although ideal in every other respect, are impracticable, as the host cannot spare a sufficient length of any large artery to replace a damaged one.

The field is therefore limited to homografts, arteries taken from an animal of the same species as the recipient, and the chief problem to be solved is that of storage. [illegible]

operation because the graft became necrotic and friable. On the other hand th tional results were very successful when the grafts were stored in a medium sir that used in tissue culture techniques, which aimed at keeping it alive. The solution used was a complicated one consisting of buffered Tyrode's solution per cent homologous serum, indicator and small amounts of penicillin and s mycin. The grafts were kept in this at a temperature just above freezing-point portions of the grafts were removed from storage at intervals and tested in culture for viability by observing whether fibroblastic activity occurred. Grafts more than 40 days had no fibroblastic activity and were found to function less su fully in recipient animals. The results with the younger grafts were so encou that the technique was applied clinically when the need arose in operating patients with cyanotic congenital heart disease or long coarctations of the aort the limited period during which 15 of these patients have been observed the have functioned successfully. The grafts used clinically were obtained post m from young people who died in automobile accidents. The body in each cas opened under aseptic conditions within 5 hours of death.

Swan, Robertson and Johnson (1950) have performed homografting experi in dogs and sought to simplify the technique of Gross. The grafts were kep common refrigerator in ordinary Ringer's solution with 10 per cent dog serum in of in the more complicated buffered Tyrode's solution. Even the small quanti penicillin and streptomycin were omitted. It was finally concluded that the vi at the time of operation and possible immunological reactions were of less impor to the functional result of the graft than was the technique used in inserting it. (wider than the recipient aorta caused turbulent flow resulting in clotting started just below the proximal suture line and extended distally. To ensure succ function the final diameter of the graft should match that of the recipient aorta closely and constriction at the suture line should be avoided. Grafts stored lo than 40 days appeared to be less successful than younger ones. Histological stud grafts removed at varying times after operation showed that the intima of the g disappeared at once and was slowly replaced by new cells from the host growi from the ends. The adventitia was also entirely replaced by new fibrous tissue fror host. In the media elastic tissue survived unchanged, but the fate of the muscle f differed with the age of the grafts. In those arteries stored longer than 40 days be insertion all muscle fibres underwent hyaline degeneration and ultimately pa calcification. In the younger grafts as much as 50 per cent of the smooth muscle f survived

In any technique of grafting viable arteries two practical difficulties arise. On these is the organization required to obtain the grafts under aseptic conditions fro suitable body within 5 hours of death. The other is the short period that the g remains viable when stored. Some method of storing grafts in fixative solution m overcome both these difficulties, and it is therefore of interest to find that Pe Gross and others in 1949 reported encouraging results with aortic transplants in using grafts stored in neutral 4 per cent formalin. These functioned well with dilatation, thrombosis or rupture for periods up to 7 months. The intima adventitia were replaced from the host. The media remained and, although it bec heavily calcified, this did not interfere with the functional result. MacPherson (19 on the other hand found that grafts preserved in spirit always clotted when implar into recipient dogs.

Autologous grafts of veins are potentially more useful than those of arteries beca a patient is more likely to have a length of vein to spare from a healthy site. The su ficial femoral vein was used successfully by Johnson and his colleagues (1949) i case of Fallot's tetralogy to bridge the gap when it was found that the subclav artery would not reach the pulmonary.

The same workers studied the behaviour of autografts of inferior vena cava replacing defects of abdominal aorta in dogs. Thickening of the grafts due to deposition of fibrous tissue took place and a little dilatation in some cases but no aneurysm resulted. The grafts remained patent and functioned successfully during 14 months' study.

Suture technique was used in these experiments. No anticoagulants were used in these or in the other grafting experiments described, most of which were done in the aorta. When smaller vessels are concerned the problem of thrombosis is a greater one, and some anticoagulant technique needs to be considered. The chief disadvantage of anticoagulant therapy in arterial grafting is the risk of bleeding into the wound or haematoma formation around the graft, which may interfere with its healing and cause it to break down. Freeman, Wylie and Gilfillan (1950) suggest regional heparinization as an answer to this problem. They point out that the principle was first introduced by Murray and Best in 1935 and go on to describe their experiences in 5 patients on whom it was employed following arterial repair for various conditions. Heparin was introduced, in quantities insufficient to cause general inhibition of clotting, through a needle or polythene tube left *in situ* above the suture line.

Callow and Welch (1950) have compared different methods of restoring patency to injured arteries in order to save a threatened limb. In order to test the efficacy of the different methods a transection operation through the thigh was devised which left the limb dependent on the femoral artery alone. The femoral artery was cut across in the limbs of animals prepared in this way and various methods of restoring continuity compared.

Equal success was obtained with direct end-to-end or arterial graft anastomosis. Vein graft anastomosis with Blakemore vitallium cuffs was almost as successful in the early stages, but gave poor results later because the anastomosis became detached in many cases.

Ordinary polythene tubing, unpolished or prepared in any special way, was uniformly unsuccessful through clotting in its lumen.

Disobliteration

In 1894 Sévéréanu (quoted by Delbet, 1906) attempted to restore patency in clotted arteries by incision and breaking up the clot with a catheter. Similar attempts were made in the years that followed, but the method fell into disuse because the clot was soon found to re-form. The invention of anticoagulants enabled the principle to be reintroduced with better hope of success and dos Santos in 1947 described a method of removing the clot through two short longitudinal incisions under cover of systemic heparin.

Bazy and his colleagues have extended this work and have described their technique and results in a series of publications quoted by Reboul and Laubry (1950). Their operation which they term *endartériectomie désoblitérante* consists of the removal of the clot with an adherent part of the wall, usually intima and media, through a long incision which is afterwards sewn up with five zero silk. The extent of the clotted segment is first shown by arteriography. A relatively smooth internal surface is left which ultimately becomes covered with intima growing in from the ends. Reboul and Laubry (1950) describe the details of the technique and analyse the results. Of 93 disobliterations of the aorta or peripheral vessels 44 remained patent, 38 clotted again and 11 patients died. The mortality was highest in the aortic group. The causes of death are not stated, but full systemic heparinization must contribute by increasing primary and secondary haemorrhage. Perhaps some form of regional heparinization might prevent new clot formation without endangering the patient's life.

This approach is an interesting one, but as Reboul says the time since the operations were performed is too short to give a final opinion on its future. It remains, therefore, in the experimental stage.

ARTERIOVENOUS FISTULA

It is generally agreed that the collateral circulation past an arteriovenous fistula is extremely good, but it is often found after fistulectomy and ligation of the artery that the distal circulation in the limb is very inadequate. The explanation of this must be that the rich collateral circulation, which would be expected to bring sufficient blood to the distal limb tissues, regresses after fistulectomy and arterial ligation.

In order to test this explanation Bosher, Harper and Bigger (1949) performed a series of arteriographic studies on dogs with arteriovenous fistulae.

Arteriograms of intact arteriovenous fistulae merely show a mixed collection of poorly filled arterial and venous channels which cannot be differentiated. To avoid this skiagrams were taken immediately after fistulectomy; they showed a richer set of arterial collaterals than those obtained following simple arterial ligation on the contralateral leg. Subsequent pictures showed the collaterals to regress until they were the same size as those due to simple ligation.

The main artery distal to a fistula was seen to be dilated and this was considered to be due to retrograde flow. This dilatation, like that of the collaterals, receded after fistulectomy. In discussing the results Bosher, Harper and Bigger (1949) explain the regression of the collaterals as representing a recovery of normal vascular tone after elimination of the increased blood flow.

Holman (1949) deals with the mode of formation of collateral channels around arteriovenous fistulae in greater detail. He discusses two theories which have been put forward to account for the enlarged collateral channels and hypertrophied main artery on each side of a fistula. The first is the hydrodynamic one offered by Thoma in 1884, that the enlargement is due to increased blood flow, and the second is that it results from vasodilator substances released from neighbouring tissues as a result of diminished blood supply. Lewis, writing in 1940, favoured the second "chemical" explanation. The hydrodynamic explanation is supported by Holman's experiments in which arteriovenous fistulae were made in amputation stumps. The same changes occurred in the artery and collaterals despite the absence of a distal mass of tissue which might release vasodilator substances. The evidence suggests that the direction [illegible]

Bosher and his co-workers and Lewis agree that rapid flow is [illegible] dilatation of the channels concerned and conclude that it is the cause of the dilatation. It is difficult, however, to find a hydrodynamic explanation for this. Generally speaking, the product of velocity and pressure exerted by fluid passing through a closed channel is constant. Therefore fast-moving fluid should exert less pressure and [illegible]

OBLITERATIVE ARTERIAL DISEASE

Thrombo-angiitis obliterans

Campbell, Harris and Coller (1949) report the results of a clinical study of patients with Buerger's disease treated at University of Michigan Hospital. The main statistics [illegible] series studied [illegible] column [illegible] are not [illegible] e condi- important factors in aetiology and also that [illegible] tion is not so difficult to reach as has sometimes been suggested.

TABLE

BUERGER'S DISEASE RESULTS OF CLINICAL STUDIES

	Michigan	*London*
Period of follow-up	14 years	14 years
Number of patients	149	77
Number of women in the series	2	1
Average age at onset	34 9 years	35 years
Youngest age at onset	15 years	16 years
Oldest age at onset	53 years	48 years
[illegible]	51 per cent	31 per cent
[illegible]	18 per cent	27 per cent
[illegible]	26 per cent (of patients)	32 per cent (of limbs)
Deaths (due to Buerger's disease)	14 per cent	10 per cent
Average duration of disease before death	8 3 years	9 9 years

A diminishing rate was noted for major amputations in the later part of the series and this is attributed to improved conservative treatment. It may, however, be due also to better judgment in deciding which patients require only a minor amputation such as that of a toe. Until recent years it was the standard practice to perform a major amputation in every case of gangrene of a toe due to arterial disease.

Many will find it difficult to accept the conclusion that psychosomatic factors are an important cause of the disease These patients have good reason for anxiety in the effects of the disease itself, and it may be that this has been mistaken for the actual cause of the disease.

An interesting point in the study is the number of patients presenting with an isolated vascular lesion, such as phlebitis or upper limb arteritis, who later develop further manifestations of the disease which enable it to be diagnosed with greater certainty. This means that a diagnosis of idiopathic phlebitis or primary isolated arterial thrombosis should only be made remembering the possibility that it may be the forerunner of other features of Buerger's disease.

Another follow-up study of Buerger's disease comes from the Massachusetts General Hospital (Hamlin, Warren and Kennard, 1949). Most of the findings are in agreement with those already described. The major amputation rate is also found to have diminished in recent years, and this is attributed to early sympathectomy.

Excision of the first lumbar ganglion is considered unnecessary. The results were found to be just as good if the sympathetic excision was carried no higher than the region of the second lumbar ganglion, which also has the advantage that it does not interfere with sexual function.

Intermittent claudication

Boyd and his colleagues (1949) discuss aspects of this problem, devoting particular attention to the classification of obliterative arterial disease. The conventional division into arteriosclerosis and thrombo-angiitis obliterans is further broken down into smaller classes on pathological and clinical grounds. These are illustrated by beautifully reproduced arteriograms.

The most interesting part of the paper deals with defunctioning operations such as tenotomy. Learmonth and Boyd independently conceived the idea that claudication might be relieved by cutting the nerve supply to the gastrocnemius on the thesis that this muscle was the chief or only source of pain. In practice it proved difficult to tell which patients had pain due to ischaemia of the gastrocnemius muscle only. Boyd

therefore initiated further work to map out the distribution of pain from the major muscle groups in the leg. This was done by injection of *hypertonic saline solution* into the muscles of normal volunteers. Pain from the gastrocnemius starts in the upper half of the calf and may radiate upwards into the back of the thigh. Soleus pain starts *in the same region* but radiates downwards behind the medial malleolus. Pain from the peroneal and tibialis muscles spreads around to the front of the leg from the lateral side.

The operation which has given the best results has proved to be division of the tendo Achillis which puts the gastrocnemius and soleus muscles out of action. This can readily be done with a tenotome under brief thiopentone or local anaesthesia.

This new principle adds a valuable measure to the treatment of peripheral arterial disease. Its exact indications are *not yet rigidly defined. The best* cases appear to be those of severe claudication unrelieved or unlikely to be relieved by sympathectomy.

It is particularly indicated for claudication pain thought to originate in the soleus-gastrocnemius group on one side in a limb with reasonably good skin nutrition.

It may also be of help to older patients whose general condition is too bad for lumbar *sympathectomy.*

RAYNAUD'S DISEASE

Felder and his colleagues (1949) at the Massachusetts General Hospital present the *results of a careful and detailed study of 40 patients operated upon for Raynaud's* disease. Of these 36 per cent were found to be cured, 28 per cent to be improved and 36 per cent to have derived no permanent benefit from operation.

Evidence of return of vasomotor and sudomotor activity in the limbs was obtained from skin resistance and temperature studies. Their return was closely paralleled by *the clinical reappearance of symptoms of vasospasm.*

Recurrence of symptoms was found to take place from 6 months to 5 years after operation. After the latter period it was unlikely to occur. Results were better in patients in whom the stellate ganglion was excised or decentralized rather than left intact by a pre-ganglionic operation. The early recurrence rate was lower in patients *in whom the second and third thoracic spinal rami were severed intradurally.*

In discussing the causes of recurrence adrenaline sensitivity is dismissed because *its effects, if any, should be manifest in 2–3 weeks and actually evidence of* vasomotor activity does not return until considerably later. Regeneration may account *for some* of the recurrences, [illegible] tomy has been perf[illegible]sidua[illegible] pathways left behi[illegible]s now anatomical evidence of the existence of sympathetic pathways which do not traverse the sympathetic chain at all. *The exact mechanism whereby these fibres might take* over some of the function of those excised is still unknown.

The results of lumbar ganglionectomy were found to be much better than those of cervico-thoracic ganglionectomy, confirming clinical observation in the past.

For Raynaud's disease of the upper limb an extensive ganglionectomy combined *with intradural section of the second and third* thoracic spinal roots is recommended.

ARTERIOGRAPHY AND OTHER TECHNICAL METHODS

Thorotrast was introduced as a contrast medium for arteriography almost 20 years ago. It has several advantages over other media. It casts a very dense shadow, does not irritate the vascular endothelium or produce spasm of the vessels and has no disturbing effect upon *systemic blood pressure. It has therefore* been used extensively.

particularly in neurosurgery and in continental clinics, despite the theoretical disadvantages of its radioactivity and long half life. Definite evidence of delayed harmful effects has not been easily produced, but is now coming to light. Brennan (1949) reviews three German articles in which harmful complications have followed its use.

Wachsmuth (1948) describes the case of a young man in which extravasation around the carotid artery resulted in cicatrization and damage to the vessel ultimately requiring intrathoracic ligature. The granulation tissue removed at operation was found to produce six times the radiation which could be regarded as safe.

Bauer (1948) cites 35 cases of severe Thorotrast injury in Heidelberg in 5 years and recalls the case reported by MacMahon, Murphy and Bates (1947) in the United States of America, in which a liver sarcoma was produced in a man 12 years after Thorotrast injection. He emphasizes that it is the late results of Thorotrast such as granuloma or sarcoma formation or damage to the reticulo-endothelial system that are dangerous.

Kuhlendahl (1948) on the other hand thinks that it is only very large amounts of Thorotrast such as may be used in Germany for hepatography that are harmful and that amounts under 20 millilitres, particularly in patients past middle life, are safe. Per-Abrodil for cerebral angiography is considered quite unsuitable as a substitute.

There are newer and considerably less irritating iodine compounds now manufactured which serve well for most types of angiography. Pyelosil is a good example. Thorotrast, if used at all, should be used only in very small amounts and in old people.

A different aspect of angiography is discussed by Freeman and his associates (1949). They have used the Valsalva manoeuvre of forced expiration against the closed glottis in 13 patients to produce relative stagnation of blood and therefore better contrast in making angiograms of the aorta and other large vessels.

Open arterial puncture is performed under local anaesthesia and serial pictures are taken.

The possible dangers of the method, such as coronary thrombosis from the hypotension or cerebral haemorrhage from the subsequent hypertension, are emphasized but it is claimed that the method will sometimes produce a valuable arteriogram which could not be obtained in other ways.

Experimental arterial occlusion

Metal bands applied to close arteries in whole or part sometimes weaken the wall of the vessel because their edges cut into it. Local aneurysms may form.

Irritant plastics used for the same purpose sometimes cause damaging scar formation in neighbouring organs and yet at the same time occlude the artery too slowly.

Cooper and his associates (1949) describe a combination of the two methods which produces gradual occlusion without the drawbacks of either used alone. A tantalum band is applied over a layer of polythene on the vessel. The polythene protrudes beyond the band at each end. Occlusion is sufficiently rapid and without the danger of the edge of the band cutting into or through the vessel wall.

Several articles have appeared in recent years on the use of polythene as an irritant. The results were conflicting. At the same time polythene was being used by other workers as an inert plastic to replace defects in body tubes. It was not understood at first that the irritating properties of certain plastics depended upon the presence of plasticizers such as dicetyl phosphate. These were often trade secrets.

No worker should use plastics as irritants unless accurate information of the nature and amount of plasticizer in the compound can first be obtained.

(*See also British Surgical Practice*: Arteries, Vol. 1, page 327, S Key 37)

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COAGULANTS AND ANTI-COAGULANTS

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INTRODUCTION

It will be convenient to begin with a short description of the process of coagulation of blood, and for the purposes of this article it will be sufficient to accept the classical conception of Morawitz (1904)—the "four-factor" hypothesis—in which the process is envisaged as taking place in two phases:

(1) Prothrombin + calcium ions + thromboplastin = thrombin
(2) Fibrinogen + thrombin = fibrin

It is quite certain that this hypothesis does not include all the physical processes which are involved, but there is at present none which does so. An admirable review of an extremely complicated problem has been made by Macfarlane (1948).

Factors in phase 1

Prothrombin, a globulin manufactured in the liver, is normally present in circulating blood in great excess of the amount required to take part in the coagulation reaction. Bleeding from lack of prothrombin does not occur until its level is reduced to 15–20 per cent of the normal value. For the synthesis of prothrombin the liver requires the fat-soluble vitamin K, which ultimately forms part of the prothrombin molecule. The titre of prothrombin may be lowered in a variety of clinical conditions. These include disorders of absorption of food (dietary deficiencies, sprue, intestinal fistulae, ulcerative enteritis), conditions which exclude from the bowel the bile necessary for the absorption of vitamin K (obstructive jaundice, external biliary fistulae), and hepatic disease. There is some evidence that vitamin K may be synthesized in the bowel by bacterial action, and thus prothrombin titre may be lowered when the contents of the bowel are partly sterilized by drugs. When hepatic function is adequate, the parenteral administration of vitamin K, or of one of its even more effective synthetic analogues, in suitable doses (300–500 milligrams) rapidly (within 12 hours) raises a low prothrombin level. It may also be raised by the infusion of plasma or whole blood.

Calcium ions are necessary for the conversion of prothrombin to thrombin, but are not necessary for the conversion of fibrinogen to fibrin. Calcium ions are present in excess of what is required for completing phase 1—the minimum blood calcium necessary being 2·5 milligrams per cent.

Thromboplastin (thrombokinase) is probably not a single substance. The complex is present in most cells of the body, particularly in blood platelets, brain, lung and testis, and can be extracted from these by water. It is liberated when tissues are injured, and also when the blood platelets are spilled on to a water-wettable surface. The venom of certain snakes (such as Russell's viper) acts as thromboplastin, especially in a system where lecithin is present to act as a co-factor.

Factors in phase 2

Fibrinogen is a mixture of proteins synthesized in the liver. Before the titre of fibrinogen in the blood falls as a result of cessation of manufacture, liver damage must be

severe. *Fibrinogen* (like fibrin) may be destroyed by the normal fibrinolysin of plasm[a], a process which may be intensified after injury or after surgical operations (Macfarlan[e] and Biggs, 1946). Fibrinogen may be absent from the plasma, as a congenital deficienc[y]. It can be separated from plasma by a variety of processes, and prepared in variou[s] forms for clinical use (page 228).

Thrombin is a protein, or mixture of proteins, which converts fibrinogen to fibr[in], probably by enzymatic action. It can be separated from plasma in extremely poten[t] form, and stored as a dry powder which is soluble in normal saline solution.

Fibrin, the basis of a blood clot, forms a network composed of needle-like elements which are highly adhesive, sticking to any water-wettable surface with which they ar[e]

[illegible]

Coagulation

The natural process of coagulation comes into action after a wound, as a result of the blood encountering raw tissues yielding thromboplastin. When blood is withdrawn by venepuncture there is some tissue damage, but this may be reduced to a minimum by the use of a syringe and needle coated with sterile liquid paraffin. Under these conditions, when the blood is transferred to a glass tube, thromboplastin is liberated by platelets as they adhere to the water-wettable glass surface. However, plasma will clot after the removal of the platelets, which supports the view that a thromboplastin precursor-substance may be, as it were, free in the plasma, and be activated by contact with a water-wettable surface. The process of coagulation is shortened after injury and operation by a complex mechanism which includes an increase in the plasma titre of both fibrinogen and prothrombin, a bone marrow reaction which provides (among other cells) an increased number of platelets, and a reduction in the antithromboplastic activity of the plasma; a useful mechanism in the circumstances, which may persist for 12 days.

The absence of coagulation in the blood vessels in health is not wholly understood. The ordinary small injuries of life must provide thromboplastin locally. Several factors contribute Probably the most important is the smooth endothelial non-water-wettable surface over which the blood flows, and the fact that pathological changes which roughen the endothelial lining occur in those vessels in which the rate of flow is rapid. It is also almost certain that nature provides additional security in the form of a circulating natural anticoagulant. This is heparin, derived from the granules of mast cells, found particularly in the neighbourhood of capillaries. Heparin is a polysulphuric acid, and acts by virtue of the strong negative electric charge carried by its acid groups. Its titre is raised in anaphylactic shock, and as a result of extensive or prolonged exposure to ionizing radiations. Heparin is an anticoagulant by virtue of its antithrombic action, although some hold the view that it may also neutralize thromboplastin. Heparin can be extracted from certain mammalian tissues in a relatively pure form, which is used clinically as an anticoagulant (page 223)

Estimations of clotting time

[illegible] it is often necessary to estimate the degree to which disease, or [illegible]

gives evidence of gross impairment of the coagulability of the blood, [illegible] (and after the [illegible] significant [illegible] othrombin

until it is less than 10 per cent of the normal value, and [illegible], below the

level at which tetany usually occurs." For clinical purposes it is also necessary, in certain cases, to estimate the prothrombin titre of a patient's plasma as compared with that of a normal control. Many elaborate methods of estimating coagulation time and prothrombin titre have been evolved: three simple laboratory procedures will now be described, which are within the capacity of even relatively isolated surgeons.

Coagulation time

Blood obtained by venepuncture—Lee and White's (1913) *method*—There are required a number of small test-tubes, about 8 millimetres in diameter, syringe and sharp needle, and if possible a water-bath which is kept at 37° C. The syringe and needle must be scrupulously clean, and must be rinsed out with physiological (0 9 per cent) saline solution, the saline being ejected from the syringe through the needle with the assembly held vertically, so that saline remains in the needle. The venepuncture is made as quickly and as cleanly as possible, and 3–5 millilitres of blood are withdrawn. The needle is detached, and about 1 millilitre of blood is ejected into each of four dry test-tubes. These are tilted at half-minute intervals until a stage is reached when they can be inverted without the blood running out The mean of the four tube-clotting times is taken. Measured by this method, at 37° C., the coagulation time varies from 4 to 10 minutes.

Blood obtained from capillaries by skin puncture—Glass tubing is drawn out into a capillary tube of an internal diameter of about 1–1½ millimetres. Blood from a puncture of the lobe of the ear is drawn into a 10–12 centimetres length of this. Beginning about 2 minutes after the puncture, at intervals of about 30 seconds, a centimetre or so of the capillary is snapped off. The end-point is indicated by the appearance of fine fibrin threads between the broken ends of the tube as they are drawn slowly apart. The time taken for the end-point to be reached is from 4 to 8 minutes.

Prothrombin titre

The measurement of prothrombin titre is properly the function of a laboratory, but a crude method is given here since it is more likely that dicoumarol or one of its successors will be more widely available than laboratories.

(a) The first essential is a source of thromboplastin This may be bought commercially, but if no such preparation is available, it can be made by freeing fresh normal mammalian brain from its meninges and blood vessels, and breaking up a portion in a mortar, under repeated changes of acetone, until a coarse powder remains. In a stoppered bottle this powder keeps its potency for about three months. When thromboplastin is required for a test, about 300 milligrams of powder are incubated for 30 minutes at 37° C., with 3 millilitres of normal (0 9 per cent) physiological saline solution. The cloudy supernatant fluid is pipetted off and diluted with four times its volume of physiological saline solution.

(b) A small quantity of 3·8 per cent sodium citrate solution is required as an anticoagulant.

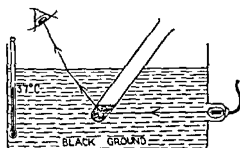


FIG 104—Method of determining the clotting time of recalcified plasma.

(c) A small quantity of calcium chloride solution (2·875 grammes anhydrous calcium chloride in 1 litre of water) is needed to recalcify the plasma for the test.

(d) If possible, a water bath at 37° C. should be available in which the tubes can be viewed against a dark ground by indirect light (Fig. 104).

Renal embolism.—It is sometimes difficult to distinguish between haematuria due to too low a prothrombin level and haematuria due to renal infarction. In the writer's experience the former is always painless, the latter may be painful.

After the occurrence of deep venous thrombosis, usually post-operative, sometimes spontaneous

This condition is potentially a danger to life, the danger being from pulmonary embolism (page 225). In an extremity—usually a lower limb—it is occasionally the cause of local or massive gangrene; and untreated or incorrectly treated it is often followed by a lifetime of misery from swelling and ulceration of the leg. Every aspect of the subject is covered in an admirable paper by Murley (1950).

There is no doubt that the efficacy of anticoagulant treatment in this condition depends on early diagnosis; for to be effective treatment must start *within 24 hours of the beginning of the process*. The results of anticoagulant treatment will vary with the ability to diagnose early thrombosis, and to some extent will depend upon a suspicious attitude on the part of medical and nursing staff, especially between the seventh and tenth days after operation when the complication reaches its maximum incidence. The most reliable sign is deep tenderness along the line of either the posterior tibial or peroneal vessels, or in one or both bellies of the gastrocnemius muscle. Tenderness may also be detected in the soles, when the plantar veins are affected. When the process reaches the femoro-popliteal trunk there is tenderness in its line, but by the time this has occurred signs of obstruction to the venous return from the limb will be present. Other suggestive features are continuing fever and raised pulse rate for which there is no obvious explanation. In any series, however, the proportion of cases in which pulmonary embolism is the first sign of peripheral venous thrombosis remains about 10 per cent, and of these cases a certain number are fatal.

This state of affairs, with its occasional tragedies in spite of the greatest care, could be improved:

(i) If it were possible to determine, previous to operation, the likelihood of a given patient developing post-operative thrombosis. A critical review of the literature and a considerable experience of these conditions lead the writer to the view that no test at present available which depends upon the examination of clotting systems *in vitro* will indicate the presence or absence of a tendency to venous thrombosis.

(ii) If the prothrombin level were reduced by coumarin therapy before operation to a point just above the level (40–50 per cent of normal) at which the coagulation time is raised. This is an attractive method, but at best it requires extreme vigilance; and so unpredictable is the effect of a coumarin drug on each individual that the method should be restricted to those cases in which there is a previous history of one or more episodes of thrombosis, excluding the pregnant woman.

(iii) If on the fifth and sixth days following operation doses of 300 milligrams and 200 milligrams of dicoumarol respectively were given, the effects of the drug would be extended over the ninth or tenth post-operative days, when the liability to thrombosis is greatest. This method would not prevent either early or late thrombosis.

After analysing a large number of cases, in which therapy of various types was employed, Jorpes (1950) came to the conclusion that the best results were seen when relatively large doses of anticoagulants were begun immediately the diagnosis of thrombosis was suspected, and with this view the writer agrees.

Moreover it cannot be too strongly emphasized that there are other preventive measures in dealing with the problem of post-operative thrombosis. These include avoidance of pressure on the calves while the patient is on the operating table, breathing and other exercises after operation, the avoidance of the Fowler position, measures to avoid abdominal distension, and early and general movements, either in bed or out of it.

Anticoagulant treatment for deep venous thrombosis of the leg (the most common site) follows the lines indicated for arterial obstruction (page 224), the leg being elevated either by raising the foot of the bed about 30 centimetres or by slinging it on a Hodgen's splint. Treatment is continued for about 10 days, until all clinical features of thrombosis have disappeared; it is of great importance that the patient should be got out of bed as soon as possible, and that on no account should the chosen anticoagulant be stopped until the patient spends much of his time out of bed in as reasonable activity as is compatible with his surgical condition.

In thrombo-angiitis obliterans

In this condition (*see* Vol. 1, page 331) thrombosis occurs in both arteries and veins. Both deep and subcutaneous veins may be affected; when occurring in the latter the condition is termed migratory phlebitis. In so pleomorphic a disease it is difficult to be sure whether anticoagulants cut short episodes of thrombosis, either arterial or venous; but the writer's clinical impression is that they are of some benefit. As thrombo-angiitis is as a rule an extremely chronic disease, several patients have been kept on an anticoagulant (Tromexan) for periods of some months, and it has proved possible to regulate dosage so as to keep the prothrombin level around 40 per cent of normal by initial repeated prothrombin estimations, and thereafter to keep it at this level while the patients resumed work, estimations being made at relatively infrequent intervals. Such treatment is logical but quite difficult to assess, and it is not recommended unless the patients are easily available to the clinician and laboratory worker.

In acute pyogenic thrombophlebitis

When acute thrombophlebitis is part of a local pyogenic lesion (acute osteomyelitis, carbuncle) it is thought that the thrombosis may lead to further local devitalization. In such acute cases heparin is the only anticoagulant available, but alone it is not wholly effective in ordinary therapeutic doses in preventing thrombosis. When it is used with penicillin, however, the spread of thrombosis is checked.

A somewhat similar problem arises in infections due to coagulase-positive staphylococci, in which the rapid deposit of fibrin in the neighbourhood of the infective focus is generally regarded as a beneficent limiting process, although it may prevent the access of antibiotics.

These two problems have been carefully studied by Sandblom, Ekström and Quist (1948), who came to the conclusion that these conditions respond to treatment slightly more rapidly and completely when heparin is administered.

In conditions produced by cold

It has been recommended that heparin be administered in such conditions as frostbite, immersion foot and trench foot, when they are severe enough to threaten the

local leakage of plasma. This process is not affected by heparin, and its use in these conditions is not recommended.

COMPLICATIONS OF ANTICOAGULANT THERAPY

It is convenient to state at the outset that anticoagulant therapy may be continued during menstruation and the puerperium, without any increase in the loss of blood. Neither heparin nor the coumarins have any toxic action in man; complications are due solely to haemorrhage. The most common complication is haematuria, and it is often a wise precaution to examine a spun specimen of urine for red blood corpuscles

each day, especially if the anticoagulant is one which reduces prothrombin haematuria has never been gross in the writer's experience. Haemoptysis occur non-fatal pulmonary infarcts, and especially when the anticoagulant is heparin it may seem to increase if the anticoagulant is continued, as it ought to be. Haemat may occur at the site of intramuscular injections of heparin, or after any anticoag when a part is palpated forcibly or massaged deeply. Petechial haemorrhage occasionally seen, as a rule in areas subjected to pressure, for example the "bec line". Haemorrhages into viscera, for example the brain, are usually quite unconn with the therapy if it has been correctly controlled.

After operations, insufficiently controlled anticoagulant therapy may be compli by haemorrhages, small or large, from any part of the area of operation.

Death from loss of blood as a direct result of anticoagulant therapy should be rare if cases are properly chosen and treatment is properly controlled. Indeed, much attention can be given to such signs as slight haematuria, which should nec tate only an adjustment of dosage. The writer has seen such a case so over-treate transfusion of fresh blood and the administration parenterally of vitamin K, thrombosis spread to the iliofemoral segment of the venous tree before adeq anticoagulant therapy was re-instituted.

CLINICAL USE OF COAGULANTS

First it must be stated that the use of coagulants does not abolish the need for car haemostasis by ordinary surgical methods: coagulants should be regarded as sup menting these.

The coagulants to be described must be distinguished from the older so-ca coagulants such as ferric chloride and turpentine, which not only precipitated proteins of the plasma but also destroyed tissue with which they came in cont and from the coagulatory effect of the ordinary cautery and of the diathermy curr They are, for the most part, substances which can take part in the ordinary proces coagulation *in vitro*.

At the stage of phase 1—prothrombin + calcium ions + thromboplastin = thrombi

There are always sufficient calcium ions in the plasma to suffice for this phase, a it is unnecessary and useless to try to decrease the coagulation time of blood by intravenous injection of excess of a calcium salt.

Thromboplastin may be obtained from a tissue rich in it, such as muscle. Especia in neurosurgery, small bleeding points can be successfully dealt with by crushing fla small piece of muscle to form a "stamp". This is placed on the bleeding point a covered with a wet pledget of wool or lint, which is then sucked dry. Gentle pressu must be maintained until the clot has formed and is secure, when the cotton is wett again and gently removed. The method is also widely useful in general surgery, f example in oozing from bone.

The venom of Russell's viper (and of certain other snakes) acts locally as thromb plastin and is especially useful in dealing with external bleeding in haemophiliacs. A extremely dilute solution, applied on a pledget of cotton-wool and maintained [illegible] blood; the loc he circulatir

At the stage of phase 2—fibrinogen + thrombin = fibrin

Fibrinogen has been prepared for commercial use largely as the result of work o the fractionation of plasma in the Department of Physical Chemistry at Harvar (Cohn and his colleagues, 1944). For clinical use it is finished either as a "fibrin foam"

a light spongy substance, or as "fibrin film". The physical properties of fibrin foam (flexibility, elasticity) can be varied during its manufacture. It is sold sterile and cannot be re-sterilized by autoclaving or by boiling without completely altering its properties. Fibrin foam may be used as a vehicle for sulphonamide drugs or penicillin.

Thrombin is also obtained during the fractionation of plasma, and is sold in the form of a sterile powder. Before its use it is dissolved in cold sterile saline solution, and kept away from any source of heat, since its activity is destroyed on heating.

Artificial substances

Gelatin sponge is a useful haemostatic, alone or saturated with thrombin.

Oxidized cellulose (Oxycel) is a non-irritating material, which is rapidly absorbed in the body without causing any immediate or late tissue reaction. It is supplied sterile, and cannot be re-autoclaved, although it can be boiled for not longer than three minutes.

Technique of using coagulants

Fibrin foam, gelatin sponge and oxidized cellulose owe much of their value as haemostatic agents to the relatively enormous water-wettable surface which they expose to escaping blood. In addition, fibrin foam (and gelatin sponge) may be soaked in thrombin solution.

Fibrin foam and thrombin

Dry fibrin foam is cut to the shape required, and about 50 per cent larger. It is then placed in the cold solution of thrombin, in which it shrinks; it is allowed to remain in this for two minutes, to allow for thorough saturation: or it may be kept in the thrombin solution until it is required. It is applied to the bleeding surface, and moulded to it, by pressure through a swab soaked in physiological saline solution, the gauze being sucked dry while pressure is maintained. It is important that the pressure be kept up for about five minutes to ensure that the blood clots on and in the bleeding surface. In haemophiliacs, whose tissues are easily devitalized by pressure, this should be gentle. When sufficient time has elapsed to allow the blood to clot, the swab is moistened and removed. Fibrin foam is absorbed readily enough without causing any tissue reaction, but if a considerable mass of it has been used to pack into a cavity (for example the prostatic cavity) it may be partly removed by scissors or scalpel, care being taken that the peripheral part of the foam is left undisturbed over the clot (Bailey and his colleagues, 1945).

Oxidized cellulose (Oxycel)

This material depends for its haemostatic effect on the large adhesive area it presents to the tissues when saturated with blood. It should be applied dry to the bleeding surface, and pressed against it as is fibrin foam. It should not be wetted with thrombin solution because the acidity of the cellulose, which confers its specific haemostatic effect upon it, neutralizes thrombin; washing the cellulose in an alkaline solution to avoid this destroys the specific haemostatic action of the gauze (Jenkins, Janda and Clarke, 1946).

In general, coagulants are useful in controlling oozing from small or large surfaces, in effecting haemostasis after incisions into organs (kidney, liver, pancreas), and in residual cavities (prostatic bed). They have been most extensively used in neurosurgery, to control oozing from the dura, from bone, from brain tissue, from dural sinuses and from cortical veins.

There remain certain special uses of coagulant substances:

(i) Skin grafts (Thiersch and split-skin) may be fixed to the recipient surface by covering it with fresh (not processed) plasma and moistening the under side of the

graft with a solution of thrombin or an extract of white blood corpuscles before pressing it into position (Clark, Milne and Todd, 1945).

(ii) The cut ends of nerves may be joined by "plasma suture". The nerves (or grafts) are held in apposition with watchmaker's forceps, in a lake edged if necessary with fibrin foam. Plasma in which additional fibrinogen has been dissolved is *dropped* on the junction, which is kept in position until the plasma clots. Excess of clot is then removed, with the fibrin foam edges (if used) (Seddon and Medawar, 1942).

(iii) An ingenious method of removing multiple small stones from the renal pelvis and calyces has been described by Dees (1944). Through a small incision in the pelvis, the pelvis and calyces are washed out. Thereafter fibrinogen solution and thrombin solution are injected simultaneously, to form a soft coagulum which entangles the stones, and which is removed through the pyelotomy incision, enlarged if necessary.

CONCLUSION

Anticoagulant drugs have provided surgery with an additional method the use of which has somewhat reduced mortality from thrombo-embolic conditions, and greatly reduced immediate and late morbidity. There are many different ways of employing them: in this article an attempt has been made to explain the principles governing their use, and to indicate certain methods which have been found safe and efficacious.

The use of coagulant drugs in surgery, except in special situations, is on the whole less extensively resorted to than seemed probable during the wave of enthusiasm which followed their introduction.

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(*See also British Surgical Practice:* Coagulants and Anticoagulants, Vol. 3, page 76, S. Key 95.)

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HAND

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INFECTIONS

It has been stated that up to 25 per cent of compensation cases resulting from industrial injury are cases of hand sepsis. Add to this the well-known high incidence in [illegible] treatment.

Classification

Loudon, Miniero and Scott (1948) give a practical classification of the clinical picture as follows:

Fingers:
- (1) Pulp infection
  - (a) distal
  - (b) middle
  - (c) proximal
- (2) Paronychia
- (3) Dorsal space infection
  - (a) middle
  - (b) proximal

Hand
- (4) Distal palmar pulp infection (web space)
- (5) Thenar space infection
- (6) Mid-palmar space infection
- (7) Hypothenar space infection
- (8) Dorsal space infection
  - (a) subcutaneous
  - (b) subaponeurotic
- (9) Tendon sheath infection

Degrees of involvement, symptoms and signs:

First degree: throbbing and tenderness

Second degree: more marked pain, redness, swelling and heat; tenderness and fluctuation

Third degree: pain, redness, swelling, fluctuation, heat, tenderness and devitalized skin

Fourth degree: the discharging hand; pain not so marked but sinus present.

Antibiotics

All workers agree that the infecting organism is in the great majority of cases a penicillin-sensitive staphylococcus or streptococcus, and therefore penicillin has rightly been given as a routine procedure by most people. The question arises as to the efficacy of systemic penicillin, particularly when the oedema and tissue tension is such that the circulation is embarrassed. Harrison, Topley and Lennard-Jones (1949), in a controlled series of 169 distal pulp infections, show that the mean healing time

after incision is reduced by 6 days, which is a significant figure. The amount of penicillin used varied between 100,000 units 3-hourly and 1,000,000 units 3-hourly. Watson, Griffiths and Plewes (1949), however, report on the results of treatment by incision with local penicillin and streptomycin post-operatively. Basing their statement on 500 consecutive cultures from distal pulp whitlows treated with local penicillin cream, and on 500 cultures from similar cases treated with streptomycin cream, they demonstrate the superiority of streptomycin as a local application. The argument for this is that the common secondary invaders, *Bacterium coli*, *Pyocyaneus* and *Bacillus proteus* are resistant to penicillin but respond to streptomycin.

Operative treatment

The old dictum that a sleepless night is a sure indication for drainage still holds true. During the early hours of the onset of the infection, conservative treatment by absolute immobilization and systemic penicillin in large doses may prevent necrosis. Once swelling has appeared, however, operation should be regarded as imminent because the local circulating penicillin concentration is then much reduced.

There are three procedures in vogue at the moment. All require adequate operating facilities, general anaesthesia and a pneumatic tourniquet. There is no place for local injection or freezing.

Incision and drainage is commonly practised, the wound being held open by a gauze wick or by a rubber sheet drain. By this method pus and necrotic material evacuate themselves naturally over a period of time, but so long as the wound remains open there is a great risk of secondary infection from the patient's skin or from careless dressing. Secondary infection means delayed healing and scar formation.

Harrison, Topley and Lennard-Jones (1949) describe the "minimal incision" in the treatment of the distal pulp space infection. The incision is made over the point of maximal tenderness with a No. 15 Bard-Parker blade, and the length of the incision is seldom more than ¼ inch. Through this, the abscess cavity is cleared of all visible necrotic material and a penicillin cream dressing is applied. In describing this technique, they stress the importance of clipping away the horny skin layer from round the proposed incision site, and this is a point worth following in hand surgery when incisions have to be made in the volar skin of the palm or fingers.

The Oxford team have described their method which is designed to promote a rapid healing rate. They open the affected site widely by transverse or L-shaped incisions, carefully excise all necrotic tissue and re-suture the wound without drainage. Their figures are strikingly good and have been corroborated by Arden, Kitchin and Powell (1949) more recently, using the same technique.

It must be emphasized that a minute knowledge of hand anatomy and practised surgical skill are necessary if this method is to be adopted.

Tendon sheath infections can be treated in the early stages by irrigation of the sheath using a needle and syringe and, when the fluid returns clear, the introduction of 100,000 units of penicillin into the sheath. In later cases the finger should be opened at the site of maximal local involvement and any necrotic tissues removed. The sheath is irrigated as before, penicillin instilled and the wound closed.

A reasonable guide to the treatment of acute hand infections would appear to be the following:

Early diagnosis and grouping of the infection.

All cases should be given systemic penicillin immediately (50,000 units 3-hourly). If swelling has not occurred, immobilize the hand and continue penicillin.

If symptoms do not abate, and if swelling is present, operation is indicated. Incise over the area of maximum tenderness, using always incisions in the creases and, if further exposure is required in the fingers, longitudinal incisions are permissible on the lateral aspects only. In the distal pulp, the minimal incision over the point of maximal tenderness

would appear to have advantages over the J-shaped lateral incision, and the old shark's mouth incision round the periphery of the nail has no place today. Make this incision parallel with the papillary ridges. All incisions have as their object either efficient drainage by natural methods, or establishing a means of access for the surgical removal of necrotic tissues.

A detailed knowledge of the part is necessary to perform a surgical excision of a slough, and it is better to rely on natural drainage than to risk severing a digital nerve.

Do not suture the wound unless all necrotic material has been removed, but if this is the case then suture is of great advantage as it results in rapid healing and absence of secondary infection. If the wound is left open for drainage, use streptomycin cream as a local dressing. Post-operative penicillin should be continued for 5 days, using twice-daily injections of 200,000 units.

Keep the hand at rest and dress as infrequently as possible Encourage movement as soon as healing is complete.

Late cases in which skin has been lost should be skin-grafted as soon as infection and local conditions allow.

TRAUMA

Burns

The treatment of burns is still a subject very much under review. The burned hand may be part of a wider thermal injury in which case the severe metabolic disturbances at times endangering life should be taken into account.

In brief, there are two phases in the systemic upset following a burn, and in the first few hours of injury it will be found that there is a marked loss of circulating plasma resulting in haemo-concentration and circulatory embarrassment. This, added to the effect of the toxic substances absorbed from the injured area, may have a profound effect which requires urgent methods to prevent an irreversible collapse. Plasma and fluid replacement should be commenced early and the administration of fluid should be controlled by serial haemoglobin or haematocrit estimations. Overloading is dangerous.

In the later stages, particularly if the wound has become infected, there may be a progressive fall in haemoglobin which should be combated by whole blood transfusions as required. This will be found to be a potent stimulant to healing.

On the local treatment of burns of the hand, the work of the Burns Unit at Birmingham has been reported by Ross (1950). The principles of treatment given are as follows:

(1) The superficial burn requires the best environment for the regeneration of its skin cover

(2) Areas of total skin destruction must be replaced as quickly as possible by skin grafts.

(3) The method of treatment adopted must allow of the earliest return of function to all [illegible]

[illegible]

It is becoming increasingly apparent that the most important feature in the treatment of burns is the prevention of infection. The plenary treatment is probably the most important event, and if badly done is the most frequent cause of a disastrous end-result.

At Birmingham an experimental air-conditioned dressing station has proved beyond doubt that burns treated under aseptic conditions can be expected to heal in a fraction of the time required by similar infected lesions. This is of great importance in the hand where oedema and scar tissue following delayed healing are the cause of so much loss

of function, and every effort should be made to keep these hands uninfected from the start.

The partial-thickness skin loss burn should be gently cleaned with cetavlon, 1 per cent, covered with penicillin cream (400 units per gramme) and completely covered with a massive pressure dressing of gauze wool and a crêpe bandage. The hand should be maintained in the position of function and elevated.

Under these conditions the majority of burns in this group will heal with full function in 12–14 days.

The whole-thickness skin loss burn is an entirely different picture. Here natural regeneration without scar cannot take place, and the necrotic tissues are an open invitation to infection. In these cases urgent surgery is indicated wherever practicable, and this should consist of a careful excision of the non-viable tissues and their replacement by a skin graft.

It is stated that 80 per cent of hand burns in this group are suitable for immediate excision and grafting, and this is a matter for the surgeon skilled in grafting procedures. Not only is the free graft used in the repair, but exposed tendons and open joints may successfully be covered by pedicle flaps at the time of excision. If this type of repair is delayed, the inevitable infection may well make it impossible by any subsequent surgical manoeuvre to regain full function.

Major hand injuries

In these days of high speeds and mass production methods, gross mutilating injuries to the hand are to be expected. The advances in reconstructive procedures are, however, such that forearm amputation is, for this purpose, a thing of the past.

Evans (1949) has shown on a series of cases drawn from heavy industry where every form of major injury has occurred that there is always some useful function to be saved provided that the principles of repair are understood.

He points out the value of primary healing, and this involves every device of skin grafting, since the surgeon must be free to discard any tissue of doubtful viability, and at the same time never to let a hand wound granulate.

With penicillin control, the immediate repair of divided nerves and tendons, the wiring of fractures and the grafting of bone losses become possible if skin cover is always available. The restitution of early function in the remainder of the hand depends largely upon the amount of structural repair undertaken at the primary operation. It is therefore useless to limit the emergency surgery to wound debridement or excision without closure, as so much secondary loss of function will occur from scarring, infection and disuse that later attempts at reconstruction can seldom hope to offer a comparable result.

It should be borne in mind that it is only too easy to attempt to conserve irreparable structures, and the time required for multiple-stage operative repair must be taken into consideration. This is particularly true in complex finger injuries where coincident tendon, joint and skin lesions should counsel amputation. A nice judgment is necessary in dealing with these problems, each of which is essentially an individual one and should be related to the patient's temperament and occupation.

Tendon injuries

Based on the stimulus given by Stirling Bunnell's great work on the hand, many contributors are reporting determined attempts to improve the outlook in injuries of this sort. All are agreed that every finesse of atraumatic surgical technique must be employed if function is to be regained, and therefore this operation should be a deliberate undertaking with full theatre advantages and the dexterity and patience necessary to ensure that no additional trauma is inflicted upon the delicate gliding surfaces.

Pulvertaft (1948) has shown encouraging results in a series of 130 cases in which he used stainless steel wire (40 gauge) as his suture material. He has not hesitated to use tendon grafts wherever required, and his analysis of recovery shows that all patients should be given the opportunity of tendon repair before amputation is considered.

If suture is not done at the time of injury, wound toilet and skin suture should be done and secondary tendon repair should be carried out within a month. If delayed longer the more complicated grafting operation is necessary.

Opinion is still divided upon the post-operative treatment. Physiological tendon union does not take place until the third week and sound union requires 5–6 weeks. It is probably the wisest course to splint the finger for 3 weeks, allowing only static contractions of the muscle after the third day and graduated active movements from the third week onwards. The final result should not be expected in under 9–12 months.

Dupuytren's contracture

The origin of this condition is still obscure, and although Skoog (1948) believes that trauma is responsible, it would seem that there is a predisposing cause in susceptible subjects The morphology of the palmaris longus system may have some connexion with the appearance of the disease.

The manifestation is frequently bilateral, most often seen in men and usually involves the fourth or fifth fingers, although any digit can become affected by the flexion contracture. This deformity is caused by shortening and thickening of the palmar fascia which, first, pulls the metacarpo-phalangeal joint into flexion, and later extends this influence to the proximal interphalangeal joint.

In the early stages the progress of the deformity can be checked by extension exercises and splintage, but usually the condition is progressive and requires surgery to prevent a crippling contracture.

The surgical operation of palmar fasciectomy should be undertaken as early as possible before irreparable secondary changes have taken place in the joints and before shortening of the digital neurovascular bundles makes straightening impossible.

In the younger patients, a total fasciectomy including the removal of the deep septa should be done, but in the later age-groups the prolonged healing time following this procedure would suggest a less radical removal. In these cases only the longitudinal bands and thin digital extensions should be excised. This obviates a deep palmar dissection, haematoma formation and subsequent scarring.

In this connexion, the older the patient the shorter should be the tourniquet time, and whenever possible it is wiser not to use a tourniquet at all. There is some evidence to show that tourniquet applications in patients over 40 years of age, except for very short periods, may have permanent deleterious effects upon the circulation and metabolism of the limb. The best surgical approach is a transverse incision in the distal palmar crease and lateral or Z-shaped incisions in the fingers. Absolute haemostasis before wound closure is essential.

Thumb reconstruction

Of the various methods of reconstruction of the thumb, the choice in any particular case should be made in reference to the patient's occupation.

There are three variables which affect the end-result, length, mobility and sensation. Of the three, sensation is probably the most important consideration, and the nearer to normal it is the more useful will the thumb be in all its finer and more delicate functions.

Thumb length is to some degree a relative matter, and in terms of function can be considered as a projection distal to the web This means that if the web is deepened as in the operation of phalangization, the effective length of the thumb is increased without alteration in its actual length. If, after consideration of the occupation, the

actual length of the stump is deemed adequate, then surgical deepening of the web either by using palmar and dorsal flaps or a skin graft will give a useful result. In this operation the greater part of the attachments of the first dorsal interosseus and the adductor brevis pollicis muscles to the first metacarpal should be divided. This has little or no effect upon the ultimate strength of the thumb.

A method has recently been described (Barron, to be published) whereby phalangization and actual lengthening with a bone graft can be achieved in a one-stage operation, which has the advantage in border-line cases of ensuring sufficient length for practical purposes. Where the metacarpal remnant is too short for these procedures there is a choice of pollicization of the adjacent finger, the tubed pedicle and bone graft reconstruction, or transplantation of the hallux. Of the three, pollicization results in normal sensation, adequate length and mobility, but lacks full power and stability and as such is useful mainly for the finer functions of the thumb.

The pedicle method will supply sensation of an abnormal kind depending upon the donor site of the skin tube. It can however with a successful bone graft become very powerful and for many heavy occupations has proved most acceptable.

Hallux transplantation should not be embarked upon without special indications, and is not at the moment included as a routine method of treatment.

Any thumb injury resulting in loss of length should be given surgical consideration but, bearing in mind the extraordinary dexterity of many people with short thumbs, reconstructive procedures should be reserved for those to whom loss in effective length is a real handicap.

(*See also British Surgical Practice*. Hand, Vol. 4, page 386, S. Key 178.)

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RADIOACTIVE ISOTOPES—CLINICAL USES

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INTRODUCTION

The value of radioactive isotopes in clinical medicine has increased rapidly since these materials first became available about 1936. Certain applications are now of established clinical importance, and the scope of these methods is widening. The following account is concerned primarily with the use of such isotopes in diagnosis and therapy. In so rapidly expanding a field, however, it is most important to consider what other applications are likely to be developed. It will, therefore, be necessary to outline the principles on which such methods depend, and the types of problem to which they have already been applied in other fields of work, where such investigations give promise of future clinical applications. The general biological applications were excellently surveyed by von Hevesy (1948), Lawrence and Hamilton (1948), and Kamen (1948), and the clinical applications by Low-Beer (1950), whose books and bibliographies will be found to be of the greatest value. The relevant physical phenomena were admirably summarized by Pollard and Davidson (1942).

Physical principles

It will be remembered that the nuclei of different atoms differ both in charge and in weight. The nuclear charge, or atomic number of an element, determines the number of electrons surrounding the nucleus, and hence the chemical properties. The atomic weight influences certain physical properties but not the chemical behaviour. Atoms of differing atomic weight but equal nuclear charge, therefore, differ physically, but are identical chemically, and are known as the isotopes of a chemical element (*see British Surgical Practice*, Vol. 7, page 262).

In all cases except that of hydrogen, the only biologically significant difference between isotopes of an element is that certain of these isotopes are radioactive, this instability occurring when the atomic weight differs from its usual proportion to the nuclear charge. These radioactive forms of the common elements are of particular value because they are metabolized in the same way as the normal forms, yet can be distinguished by their radioactivity.

At the moment when an atom undergoes radioactive disintegration, radiation is emitted which is readily detected by the Geiger-Müller counter. The frequency with which such radiations are detected, therefore, measures the frequency with which atoms are disintegrating in the vicinity of the counter, which in turn is proportional to the number of radioactive atoms present. The "counting rate" observed is, therefore, a simple and highly sensitive measure of the local concentration of a radioactive isotope.

This method holds for various types of radiation which may be emitted. *Beta* radiation consists of a discharge of electrons, which is readily detected, but only penetrates through a few millimetres of water or tissue. The concentration of isotopes in samples of body fluids may, however, be determined accurately by this means. *Gamma* radiation, which is also emitted by most radioactive isotopes, has the great advantage

that it can penetrate many centimetres of water or tissue. In this way the amount of radioactive iodine in the thyroid, for example, may be determined with a suitable counter placed opposite the neck, and the progressive concentration of radioactive iodine by the gland may be followed in the living subject, provided that the position of the counter relative to the gland is kept constant.

Clinical applications

It will be seen that the possible applications of radioactive isotopes fall into several groups.

(*a*) The distribution of an administered isotope throughout the body may be examined by *gamma* radiation measurements at different sites, or occasionally a distribution in superficial tissues can be studied if energetic *beta* radiations are emitted. Three clinical groups are important.

(i) After allowing time for an isotope to reach its equilibrium distribution in the body, an external counter can be used to identify the body areas in which the isotope [illegible]

taining radioactive iodine.

(ii) An external counter can be used to record the moment at which an administered isotope arrives at a particular site, as in measurements of circulation time.

(iii) The spatial distribution of an isotope within the body may be mapped using biopsy specimens.

(*b*) *The distribution and metabolism of the isotope may be followed by analysing* body fluid or other samples which are removed and tested for their isotope content at *various times after administration, or for the appearance of the isotope* in different chemical fractions of the samples. Two important types of investigation may be recognized.

(i) After administration of a known amount of an isotope, its concentration in tissue fluids is used to determine the "diffusion space" of the substance or the increase of this space with time.

(ii) The appearance of the isotope in certain fluids or in a certain chemical form may measure the rate of metabolism or the efficiency of utilization of a substance.

(*c*) The radiations may be used, not to record the presence of the isotope, but to produce local tissue changes. Such therapeutic applications require considerably higher dosage and fall into two groups.

(i) *The radioactive isotope may be placed at the sites to be irradiated* by mechanical means.

(ii) *Concentration at the required sites* is effected by body processes, either on account of the chemical nature of the radioactive element, molecule or structure which [illegible] physical form [illegible] lated from each other, and many [illegible] ods with other forms of analysis. It may be useful, however, to illustrate the value of each type of investigation *in turn so* that future application can be more easily envisaged.

DISTRIBUTION OF RADIOACTIVE ISOTOPES WITHIN THE BODY

Counter shielding

The closer a simple counter is brought to a source of radiation, *the faster* will be the counting rate recorded. An unshielded counter will thus give rapid counts when over an area of high radioactive *isotope concentration* in the body, but will also be

influenced by radiation from other parts of the body. In order to map accurately the distribution of a radioactive isotope at different points below the body surface, the

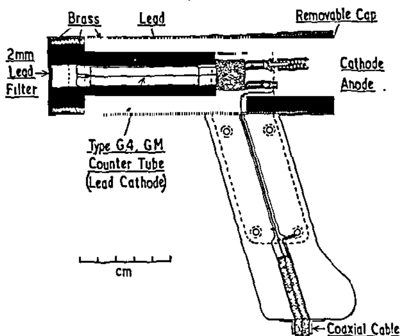


FIG 105—Lead cathode directional counter with 2-millimetre front lead filter for differential screening of scattered radiation from iodine 131.

may be compared with the outlines of palpable structures (Fig. 107).

The precision with which a radioactive source can be outlined, or adjacent sources discriminated, will be affected by the amount and arrangement of shielding. High precision is normally obtained at the expense of sensitivity, so that either an increased dose or longer periods of counting at each position must be used. Counter shielding should, therefore, be designed for the requirement of each particular problem, both as to the precision or discrimination required, the dose permissible, the presence of active sources adjacent to the area to be examined, the size of area to be mapped and the length of examination which patients should undergo. The use of the more sensitive scintillation counters and of isotopes with short half-period and relatively soft *gamma* radiations will in general facilitate localization. Inaccuracy in localization may result from secondary radiations diffusely scattered within the body, and light metal shielding of the open end of the counter shielding may be used for differential reduction of this scattered radiation relative to the primary radiation emitted directly from the source itself.

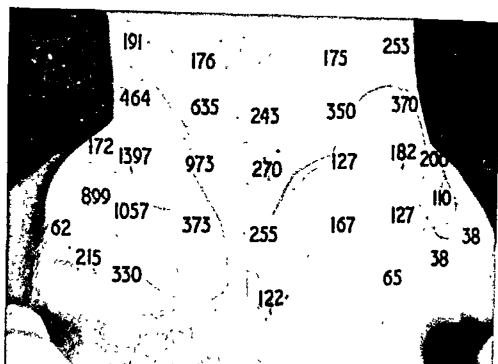


FIG. 106.—Counting rates observed (counts per ½-minute) at different points in the neck of a patient in whom a thyroid carcinoma involved principally the left lobe, with metastasis in a left supraclavicular gland. (*By courtesy of Lancet*)

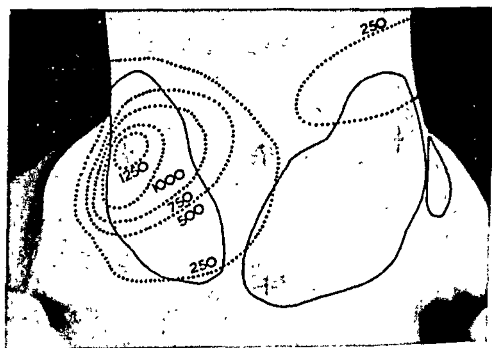


FIG.

Localization of iodine-concentrating tissues

The position of thyroid tissue may be accurately localized by simple directional counting methods after giving small doses of radioactive iodine. It is convenient to allow from 2 to 4 days between administration and counting, so that iodine concentration by thyroid tissue is complete, and counts are not obtained also from iodide in circulation or in the kidneys and bladder during its excretion. Over thyroid tissue, sufficient activity will be observed for an accurate count to be made at each position in half or one minute, unless a highly directional counter is used.

This method has been effective in the identification and mapping of retrosternal goitres (Ansell and Rotblat, 1948); and of cases of lingual thyroid (Schilling, Karr and Hursh, 1950; Dargent and others, 1950; Feitelberg and others, 1948), and has been used to investigate the completeness of removal of an ovarian thyroid struma. It has been of value in confirming the normal position of a thyrotoxic but impalpable gland pre-operatively; and in demonstrating the absence of thyroid tissue in a patient remaining thyrotoxic after total thyroidectomy, other evidence subsequently indicating thyroid self-administration as the cause for symptoms. The *gamma* radiation energy of radioactive iodine 131 ensures that active thyroid tissue at any depth in the body would be detected.

Dobyns, Skanse and Maloof (1949) have extended this type of analysis to distinguish those nodules of a nodular goitre which concentrate radioactive iodine actively from less active tissue or nodules; and have compared their findings with analyses after thyroidectomy. Except with large nodules, the effects of underlying and probably of [illegible]

In the examination of cases of thyroid carcinoma, particularly with metastases remote from the thyroid, external counting is an important step, since those cases in which the carcinoma can be shown to concentrate iodine actively are suitable for radioactive iodine therapy. The level of iodine concentration in such tumours is rarely great and may only be demonstrable after total thyroid removal or destruction. Its demonstration is not likely to be difficult where a concentrating metastasis is many centimetres distant from any other iodine concentrating tissue. It may, however, be impossible to establish or disprove weak iodine concentration either in a primary tumour in a lobe still containing normal thyroid tissue, or in a metastasized lymph gland closely adjacent to normal thyroid tissue, and in such cases biopsy after radioactive iodine is more informative.

Radioactive iodine in combination with thyroxine or certain other organic compounds is concentrated initially in the liver, and may be located there by external counting. No clinical application has been suggested.

When combined with fluorescein, radioactive iodine can be used to examine areas in which the dye is selectively concentrated, and the localization of cerebral tumours, in which such concentration may occur, has been attempted by numerous investigators with variable results (Ashkenazy and others, 1949; Moore and others, 1948; Belcher and Evans, 1951). It is not clear whether any local concentration of the labelled dye in tumour tissue is due to abnormal vasodilatation, the capillaries being locally permeable to the dye, or whether an increased blood content of the tumour tissue is responsible for any effects observed. In several series of cases consistent localizations have been observed, but in other work determination of the affected side has been found to be difficult or impossible, even when the scintillation counter is used. This type of method appears to have future promise for vascular tumours in avascular regions generally, but had not up to October 1950 achieved clinical importance in the routine study of cerebral tumours

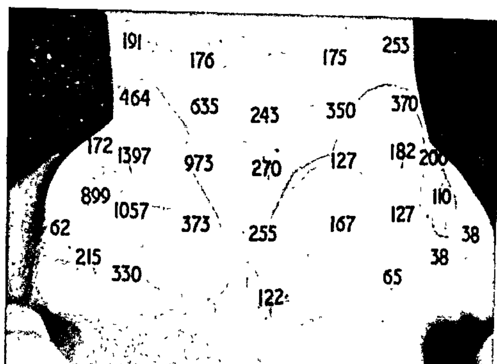


FIG. 106.—Counting rates observed (counts per ½-minute) at different points in the neck of a patient in whom a thyroid carcinoma involved principally the left lobe, with metastasis in a left supraclavicular gland. (*By courtesy of Lancet*)

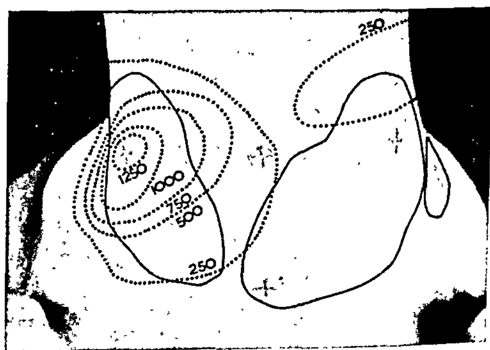


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importance.

To distinguish cases of arterial disease of the legs, however, this method must include measurements of the subsequent accumulation of radioactive sodium by the [illegible] the speed [illegible] and speed with which arterial [illegible] as an index of blood flow. *He injected radioactive sodium locally into the tissue of which* [illegible] the rate of removal. It appears to [illegible] have been made of calf muscle circula- [illegible] mass and speed of injection, of vasodilator effects of the solution and of exercising the muscle during the test, are not yet fully understood, and it seems probable that the correspondence between the results of such tests and clinical findings could be im- [illegible] clinically important, since it is potentially [illegible]

to test the earliest time of adequate vascularization of skin flaps (Roswit, 1950), and this author claims that the stages of pedicle grafting may be successfully accelerated when rapid radioactive sodium removal from the pedicle is used as an indication of vascularization.

Prinzmetal and others (1949) have adapted the radioactive method of recording blood flow to investigate the time and manner of transfer of blood from the right to the left ventricle of the heart. Radioactive sodium is given intravenously by rapid injection. A counter records the arrival of radioactive blood in the heart. The recorded activity then falls as most of the labelled blood is discharged into the lungs, but rises again as it enters the left side of the heart. In cardiac disease, the forms of the curves, and the interval between peak activities in left and right heart, are altered.

The rate of blood flow in veins has been examined by Wright, Osborn and Edmonds (1950) during pregnancy and in cases of venous thrombosis, injections being made into foot veins and a counter placed at the groin. This method is clearly applicable, and has been used, to investigate cases in which obstruction of venous return from other areas is suspected. In experimental work on dogs, the effect of artificial respiration on blood movements after circulatory arrest has been examined by similar means (Thompson, Quimby and Smith, 1946).

The progressive diffusion of radioactive elements through the tissues of the hand has been shown to give information on tissue composition. It is known that certain gases diffuse at different rates into aqueous and lipoid materials. When the accumulation of radioactive argon in the hand was examined, it was possible to distinguish a phase of rapid saturation of one, presumably aqueous, component of the tissues, and a slower penetration into the lipoid component.

Localization of other radioactive elements

Certain other radioactive isotopes have been tested for cerebral tumour localization without clear evidence of greater success. Potassium appears to be locally concentrated in some cases, possibly again owing to greater vascularization, and phosphorus (Selverstone and Solomon, 1948) would probably be of value for superficial tumours if its emission, which is of *beta* radiation only, had adequate tissue penetration. It has been shown that superficial carcinoma, for example of the breast, may be localized, using radioactive phosphorus (McCorkle and others, 1948), benign and most inflammatory lesions causing some, although less, local concentration. Phosphorus has also been said to have value in the differential diagnosis of testicular tumours (Roswit, Sorrentino and Yalow, 1950), and may be concentrated in osteogenic sarcoma and secondary tumours of the breast. Considerable experimental work on animals suggests that these or similar methods may prove of value, but their present clinical scope consists more in the demonstration of known lesions than in diagnosis or differential diagnosis. Radioactive bromine, when introduced into trypan blue, allows good localization of tissues concentrating the dye selectively (Moore and Tobin, 1942), and it is of some importance that carbon 11 has radiations just energetic enough to be detectable by external counting in man (Tobias and others, 1945).

No detailed study has been made with *gamma*-emitting radioactive isotopes in compounds which will remain within the blood stream. The localization of vascular tissues is likely to improve when this subject is more fully examined, and an important [illegible] soluble by this means. Similar methods are of [illegible] concentration relative to surrounding tissues, advances would occur in diagnosis as well as in possible therapy.

It should [illegible] concentrate an isotope selectively, their [illegible] of x-ray pla[illegible] zinc in liver and other tissues by this means, and the distribution of radioactive gold in the abdomen after its intraperitoneal injection. The localization of radioactive iodine in thyroid tissue may be similarly illustrated, but the method is in general much less sensitive than by making counts in selected positions over the area concerned.

PASSAGE OF RADIOACTIVE ISOTOPES THROUGH THE BODY

Measurements of circulatory rates

Hamilton and Stone (1937) showed that radioactive materials could be injected intravenously into one arm and their arrival in the other arm recorded accurately by Geiger-Müller counter. This principle has been widely applied, using radioactive sodium as indicator. This isotope is convenient, since it has powerful *gamma* radiations which penetrate tissues readily, although causing some difficulties in suitable screening. On account of the short half-life, a dose can be given which has high activity at [illegible] rapidly to low [illegible]

Smith and Quimby (1947) have recorded the interval between [illegible]ion and arrival of radioactive sodium in the foot in cases of arterial disease of the legs. Counters are commonly placed against the sole of the foot and the arrival of blood labelled with radioactive sodium (Murphy and others, 1950) or radioactive phosphorus (Friedell, Indeck and Schaffner, 1950) can be accurately timed by registering the moment at which the counting rate begins to rise. Many conventional measurements of circulation time depend upon the arrival, for example at the tongue, of a sufficient

concentration of a chemical substance to stimulate a taste sensation which is then recorded. With the radioactive method, provided that an abrupt rise in counting rate is observed and the effects of blood in remote tissues are eliminated, the first arrival of labelled blood is measured, eliminating delays in building up of concentration and recording of sensation. The method is objective, and is adaptable to measurements at many sites or in children. Injecting if necessary by cardiac catheter or intra-arterially, it could be used to give detailed information in a variety of special cases of clinical importance.

To distinguish cases of arterial disease of the legs, however, this method must include measurements of the subsequent accumulation of radioactive sodium by the limb (Smith and Quimby, 1947). Presumably the arrival time may indicate the speed of blood flow in larger vessels only, while the subsequent course of the counting rate measures the progressive diffusion of radioactive sodium through the extracellular fluids, and thus offers a more exact test of the efficiency and speed with which entering blood supplies the tissue mass with its metabolic requirements.

Kety (Bing and others, 1949) proposed a simpler measurement of tissue fluid mixing as an index of blood flow. He injected radioactive sodium locally into the tissue of which the blood flow was to be determined, and measured the rate of removal. It appears to be established (Stone and Miller, 1949) that this method gives a valid measure of the venous fluid removal, and therefore of entering blood volume per minute, if the tissue volume is in equilibrium. Many measurements have been made of calf muscle circulation by this method, but the results for muscle in the resting state are commonly normal even though exercise of the muscle causes typical claudication pain. The results of mass and speed of injection, of vasodilator effects of the solution and of exercising the muscle during the test, are not yet fully understood, and it seems probable that the correspondence between the results of such tests and clinical findings could be improved. If so, the technique should become clinically important, since it is potentially applicable to viscera as well as to different sites and types of somatic tissue, and since the principles on which it rests appear to be of wide validity. It has already been used to test the earliest time of adequate vascularization of skin flaps (Roswit, 1950), and this author claims that the stages of pedicle grafting may be successfully accelerated when rapid radioactive sodium removal from the pedicle is used as an indication of vascularization

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Measurements of thyroid uptake

Numerous investigations have been based on measuring the rate with which the thyroid takes up radioactive iodine from the blood. If a dose is given orally or intravenously as iodide, the rate of thyroid uptake an hour later may be expressed as the percentage of the dose being taken up by the thyroid per minute. If this figure is compared with the plasma concentration at the time, in percentage of the dose per millilitre of plasma, a value is obtained for the thyroid clearance rate, measuring the volume of plasma cleared of its radioactive iodine by the gland each minute. In normal subjects between 10 and 50 millilitres are usually cleared per minute, the value in Graves's disease normally exceeding 100 millilitres per minute (Pochin, 1950). In myxoedema the clearance is usually below 3 millilitres per minute and the test should give a reliable diagnosis of degrees of hypothyroidism which are insufficient to cause myxoedema.

The level of the thyroid clearance rate is reflected in a number of allied tests which are simpler to perform. A high clearance in Graves's disease is normally associated with a low urinary excretion of radioactive iodine in 24 or in 48 hours, a low plasma radioactive iodine concentration 2 hours after administration, a high protein-bound radioactive iodine at 24 hours and a high ratio between counts over the neck and the thigh 2 hours after the dose. Keating and others (1949) and Astwood and Stanley (1947) use other measures of radioactive iodide uptake rate and assess the efficiency of antithyroid drugs in man by this means (Stanley and Astwood, 1949). Such tests of iodine uptake have been used to distinguish cases of myxoedema due to thyroid atrophy from those due to pituitary hypofunction in which the iodine uptake may be restored by thyrotropic hormone (Reiss and others, 1949).

DISTRIBUTION OF RADIOACTIVE ISOTOPES WITHIN BODY TISSUES

Biopsy material may be examined either for radioactive isotope distribution or for content. The distribution is normally studied by radioautographs, in which thin sections of tissue are placed against x-ray film so that exposure occurs at sites of radioactive isotope concentration within the section. The total content may be determined with greater sensitivity and speed, either by exposing the tissue at a known distance from a *gamma* radiation counter or by introducing a tissue extract into a liquid counter. Such biopsy methods are important, for example in recognizing weak iodine uptake in thyroid carcinoma tissue. Local fogging of the radioautograph over the tumour will be recognizable microscopically if the radioactive iodine concentration exceeds about 1 microcurie per millilitre of tissue. On the other hand, about 0·1 microcuries or less can be identified by the *gamma* counter (without using scintillating counters) and 0·01 microcuries by liquid counter measurements on 10 millilitres of extract. In these cases it is necessary to compare counts or extracts from an equal bulk of a control tissue such as muscle obtained at the same time, if the concentration ratio of radioactive iodine in the tumour tissue is to be established.

Radioactive phosphorus has been used to assess the vascularity of the femoral head at operation (Tucker, 1950) and similar methods may prove to have a wide application. Radioactive phosphate is given an hour before exposure of a fractured neck of the femur. At exposure, a chip is taken from the head and its radioactive phosphorus content determined. The extent to which the electrolyte given an hour previously has entered the bone gives some measure of the adequacy of the bone circulation.

The mechanism of tooth formation has been extensively studied by similar methods. Radioautographs of bone and teeth have been made with many different radioactive elements in a study of the sites within bone in which these elements are deposited. In post-mortem examinations on man and animals, radioactive materials have been of value in mapping the tissue distribution of material injected through single vessels

such as the coronary (Prinzmetal and others, 1947) or bronchial (Bruner and Schmidt, 1947) arteries, and branches of the portal vein (Hahn, Donald and Grier, 1945). The accumulation of sulphur in tumours of cartilage (Layton and Frankel, 1949) and gold in joint structures during experimental chemical arthritis (Bertrand, Waine and Tobias, 1948) have also been demonstrated by using radioactive isotopes and have possible clinical applications.

STUDY OF DISTRIBUTION SPACES

Blood volume investigations

If a sample of blood is equilibrated with sodium phosphate containing radioactive phosphorus, the red cells become firmly "labelled" with radioactive phosphorus (Hahn and von Hevesy, 1942). If a known volume of such cells is reintroduced into the circulation and, after mixing, a further blood sample is withdrawn, the blood volume is determined from the degree to which radioactive phosphorus is diluted in the second sample as compared with the injected blood.

Apart from studies of total blood volume in various pathological conditions and comparisons of the venous with the average total haematocrit, this method has been extended by Nylin to analyse the amount of circulating blood normally present in various organs. This may be done if the circulating blood volume is first determined while the circulation to part of the body is arrested, and is then re-determined after the local circulation has been released. The method has been applied to the leg blood volume and to that of one lung before pneumonectomy (Nylin, 1947). By analysis of blood mixing, Nylin (1945) has also studied the volume of blood remaining in the failing heart at the end of ventricular systole. He has shown that some of a sample of labelled blood injected into the right ventricle will normally have completed its circulation through the body and returned to this ventricle after 7 to 9 seconds (Sutton, Karnell and Nylin, 1950) It has also been possible to demonstrate that the circulating cell volume does not increase during exertion in man, as occurs in dogs from splenic contraction.

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the disadvantage that iron liberated from lysed cells is efficiently used in newly formed cells, so that the "label" becomes transferred from the original cells.

Electrolyte and other spaces

The diffusion spaces of sodium chloride, iodide and certain other electrolytes have been examined in health and in various pathological conditions; and the total body water has been measured using both isotopic forms of hydrogen, deuterium and tritium (Pace and others, 1947). In all such cases, if the total excretion of the isotope is known, the unexcreted quantity may be determined and compared with its concentration in the plasma. In this way the body space can be expressed as the volume which would contain this quantity of isotope at a concentration equal to that in plasma. Such data may be used to estimate extracellular fluid volume more reliably than with thiocyanate. In many medical and surgical conditions it will clearly be of the greatest value if the blood volume, extracellular fluid volume, body water and electrolyte shifts can be followed readily, and in particular the general therapy of cases with extensive burns is considerably facilitated by such information.

Fink and others (1944) have examined the blood concentration of plasma proteins labelled with a stable nitrogen isotope administered intravenously, and find evidence consistent with their distribution through a space several times that of the blood

volume. Fine and Seligman (1943) have used radioactive iodinated plasma *proteins* in dogs and have found no evidence of a generalized capillary permeability to protein in traumatic or haemorrhagic shock.

METABOLIC RATES STUDIED BY RADIOACTIVE ELEMENTS

Iron metabolism

The absorption, circulation, storage and utilization of iron in human anaemia has been very successfully studied by the use of radioactive iron (Hahn, 1948), or by separate labelling with its two available and distinguishable isotopes of atomic weights 55 and 59. These tests are now of diagnostic importance in cases of refractory or obscure anaemia, and have clarified the mechanism of anaemia considerably. The absorption of different forms of iron, and its dependence on age (Darby and others, 1947) and infection (Wintrobe and others, 1947), have been studied in detail. It is shown that, whereas the intestinal absorption of iron is accelerated in chronic anaemia, it is not increased after acute blood loss until certain body iron stores have first been depleted.

The supply of iron to the foetus, and the evidence for passage of red cells across the placenta (Naeslund and Nylin, 1946) and across the healthy peritoneum (McKee and Stewart, 1950), have been studied by radioactive iron or radioactive phosphorus labelling; and the selective invasion of recently formed red cells by malarial parasites (Ferrebee, Gibson and Peacock, 1946) illustrates a phenomenon which could not have been observed without such labelling methods.

Liver metabolism

Very extensive work on phospholipid metabolism in mammalian liver and brain has been carried out by Chaikoff (1942) and others using radioactive phosphorus. Comparable observations in man have recently been reported, both on the rate of phospholipid turnover revealed after radioactive phosphate administration (Cornatzer and Cayer, 1950, Cayer and Cornatzer, 1950), and on the incorporation of methionine containing radioactive sulphur into plasma proteins (Kinsell and others, 1950). The [illegible] appears to be influenced in liver disease and in cases of hypoproteinaemia. [illegible] methionine into cystine [illegible] protein synthesis has [illegible] most of the globulin and almost all albumen synthesis was shown [illegible]er.

Measures of circulatory function

Threefoot, Burch and Reaser (1949) have used radioactive sodium to examine the speed with which circulatory and interstitial fluid mixing occurs, particularly in cardiac disease and nephrotic oedema, and the speed of sodium excretion as compared with [illegible] (1950) have also investigated the action [illegible] which [illegible] (1949) [illegible]

heart failure. It is likely that analyses of post-operative circulatory [illegible] measures of mixing times and fluid or electrolyte shifts are likely to give valuable information.

Other applications

The synthesis of penicillin with a high content of radioactive sulphur has allowed detection of very small amounts of penicillin (Rowlands, Rowley and Smith, 1949), as little as 0 002 i.u. being measurable. Penicillin labelled in this way is being used to investigate its site of action on bacterial bodies (Cooper, Rowley and Dawson, 1949).

Schoemheimer (1942) has used stable isotopes of nitrogen and carbon to show that many body constituents, such as adipose tissue, are not static structures, but are in a constant process of solution and replacement. It has now been shown that even compact bone is continuously although slowly replaced (Neuman and Riley, 1947). Each of its constituent apatite crystals remains intact without chemical change for a period which differs in different species. It then breaks down and is replaced from the available circulating electrolytes. As with other structures, the pattern of the tissue persists, but its composition changes constantly. The phosphate of urine has been shown to exchange in a somewhat similar manner to that of calculi in the renal pelvis (Benjamin and others, 1950), and extensive studies have been made on the dependence of tooth structures upon blood salivary constituents.

LOCAL RADIATION THERAPY USING RADIOACTIVE ELEMENTS

In many respects the use of appropriate radioactive elements has extended the range of therapy previously dependent upon radium and radon implantation. Various *gamma* emitting isotopes have been proposed or used in place of radium. Either cobalt or iridium may prove adequate substitutes, either in the form of wire or "seeds" or as external sources of radiation (Myers, 1948; Nickson, Lamerton and Mayneord, 1949).

Radioactive phosphorus (Low-Beer, 1947) and other radioactive elements (Friedell and others, 1950; Freundlich, 1949) have been used as convenient sources of *beta* radiation for surface application. It is of importance that different isotopes are available with a range of radiation energies, so that radiation to different tissue depths can be selected. Tritium, a radioactive hydrogen isotope, has been discussed as a source of soft *beta* radiation likely to be of value in therapy of the most superficial tissue layers.

In the irradiation of body cavities, the radioactive isotopes are likely to have increasing value also since, in many cases, the material may be introduced in a form which ensures that it will remain in the cavity. It may then be left *in situ* if the half-period of radioactive decay ensures that radiation of the cavity walls will continue for the requisite time. Radioactive gold, if injected intraperitoneally in colloidal form, largely remains within the peritoneal cavity and its activity is halved every 2·7 days (Muller, 1950; Hahn and others, 1947). It has been used to decrease the formation of ascites in the treatment of peritoneal carcinomatosis, and appears to have a useful palliative effect in certain cases. Its short half-period makes it [illegible] the radioactive inert gases, xenon or krypton, might be of value in cavity radiation.

Many isotopes have been used in colloidal form (Hahn and Sheppard, 1948) for local infiltration into carcinomatous tissues, particularly in carcinoma of the breast. It is still too early to state either the best method or the results of treatment by these means, but they clearly offer a highly controllable distribution of radiation, particularly where an active *beta* radiation is emitted which will have effects within a few millimetres of each injection mass. Two extensions of this principle have been tested [illegible] intravenously to mice, nuclear fission of the uranium was caused by neutron irradiation, and histological effects were observed particularly in liver, spleen and kidneys, in which the colloid had been concentrated (Tobias and others, 1948).

In the treatment of papillary carcinoma of the bladder, both radioactive cobalt (Muller, 1949c) and radioactive sodium (Wallace, Walton and Sinclair, 1949) have been used successfully, a solution of the isotope being introduced into a bag placed within the bladder. Of the two materials, radioactive sodium is much less hazardous,

since it has considerably the shorter half-period, of 14·8 hours as against 4 years, so that the risk of radiation injury to the patient in the event of escape of the solution from the bag is considerably diminished. It is of interest that Simon has been able to suppress gastric acidity in dogs' gastric pouches by the application of a bag containing radioactive phosphorus (Simon, 1949).

For any particular therapeutic problem involving local irradiation, the required tissue distribution of radiation may suggest a particular isotope as suitable for treatment. Since the many isotopes which are now readily available vary widely in the energy of their radiations, in the length of their effective action as judged by half-period of decay, and in the physical state in which the element can be prepared, it is evident that local radioactive isotope therapy may be developed to include a variety of special purposes. While these may not differ in principle from the existing methods of radium or radon therapy, they are clearly likely to increase the versatility of such radiotherapeutic methods.

THERAPY DEPENDENT ON SELECTIVE CONCENTRATION OF RADIOACTIVE ELEMENTS

If any element is more highly concentrated in one tissue than in another, the corresponding radioactive element will cause greater irradiation of the former tissue (Marinelli, Quimby and Hine, 1948). If most of the tissue ionization is due to *beta* radiation, as it usually is, then the tissue dosage rates will be approximately proportional to the tissue concentrations of the isotope at the time. Iodine may be concentrated over *100* times as highly in thyroid tissue as in other tissues. Thyroid tissue may therefore be destroyed by administering an amount of radioactive iodine which barely affects lymphoid tissue or bone marrow, despite the greater sensitivity to radiation of the latter tissues. Similarly any thyroid carcinoma which concentrates iodine more than 50 times as highly as other tissues can probably be treated successfully. When [illegible] the degree of selective [illegible] oncentrating [illegible] *sensitive to* [illegible]

complex molecules or histological structures with which a radioactive isotope [illegible] combined. These principles are of general application, and it is most probable that the scope of this type of therapy will widen, perhaps dramatically, if elements, compounds or structures are *found which selectively* enter pathological tissues in concentrations higher than in tissues as vital and sensitive to irradiation as bone marrow and lymphoid tissue. It may be noted that we cannot be guided simply by the normal chemical concentration ratios. For example, a tissue may be iodine-rich because it concentrates either inorganic iodide or thyroxine. If a radioactive iodine is used which decays to low activity before the body has incorporated it into *the thyroxine molecule*, the iodide concentrating tissues only will be selectively irradiated. If radioactive iodine of long half-period is used, thyroxine concentrating tissues will also receive some selective concentration. Only from elements with long half-periods will the selective radiation necessarily conform with the chemical composition of tissues.

Radioactive iodine therapy of Graves's disease

A tissue *dose of*, or rather over, 10,000 röntgens to the thyroid will commonly cause a full and permanent remission of thyrotoxicosis in patients with Graves's disease (Chapman, Skanse and Evans, 1948; Williams and others, 1949; Werner, Quimby and Schmidt, 1949; Kelsey, Haines and Keating, *1949*; *Williams*, 1949;

Prinzmetal and others, 1949; McCullagh, 1950; Feitelberg and others, 1950; Haines, 1950). Such a dose can be achieved by the oral administration of a few millicuries of radioactive iodine, which is without detectable effects on the rest of the body. The treatment is potentially of wide application in Graves's disease, and may become of general use in uncomplicated cases. At present, however, many clinicians use this treatment only on older patients and on those for whom thyroidectomy and thiouracil treatment are unsuitable. Several considerations influence this decision.

necessary to establish whether such a sequel is theoretically possible, but whether it is more probable than death from operation, from thiouracil treatment or from the omission of treatment.

(*b*) Health precautions, electronic equipment, and facilities for measuring and storing radioactive urine are necessary in such treatment and are not generally available.

(*c*) Correct dosage is not easily estimated even when a preliminary tracer dose is given to estimate the thyroid uptake and retention of radioactive iodine, since the sensitivity to irradiation of different toxic goitres varies widely. The tissue dosage in rontgens depends also on the size and uniformity of the goitre which cannot be accurately estimated. Myxoedema may, therefore, be caused in a proportion of patients.

The main uncertainty in dosage depends upon gland size and sensitivity. The variations in uptake and retention in different cases of untreated Graves's disease are small relative to probable errors in estimating gland size, and the omission of a tracer dose, therefore, appears justified If average figures are assumed for uptake and retention within the gland, the thyroid will receive about 10,000 rontgens if the dose in millicuries is one-tenth of the estimated gland weight in grammes. The average ratio between the total necessary dose in millicuries and the estimated gland weight in grammes appears to vary in different clinics between one-eighth and one-quarter. The average total dose needed for control of a toxic nodular goitre is found to be rather higher than for a diffuse goitre (McCullagh, 1950). The only recognized complications of this treatment, unless late carcinogenesis is a significant hazard, are:

(*a*) occasional exacerbation of symptoms for a few days in the first week, and possible tenderness of the gland at this period.

(*b*) myxoedema in about 10 per cent of cases A few cases become myxoedematous on low doses, so careful fractionation of the dose is insufficient to prevent all cases, *although it may be expected to reduce the frequency*, particularly if the progress of treatment is followed by radioactive iodine tests of thyroid function.

Blood changes are not observed, and ovarian or testicular irradiation is almost certainly unimportant in amount.

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thiouracil has failed or has not been tolerated If the fear of late carcinogenesis can be shown to be unfounded, radioactive iodine may become the treatment of choice except in the presence of pressure symptoms, late pregnancy (Chapman and others, 1948) or possible malignancy.

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complex molecules or histological structures with which a radioactive isotope is combined. These principles are of general application, and it is most probable that the scope of this type of therapy will widen, perhaps dramatically, if elements, compounds or structures are found which selectively enter pathological tissues in concentrations higher than in tissues as vital and sensitive to irradiation as bone marrow and lymphoid tissue. It may be noted that we cannot be guided simply by the normal chemical concentration ratios. For example, a tissue may be iodine-rich because it concentrates either inorganic iodide or thyroxine. If a radioactive iodine is used which decays to low activity before the body has incorporated it into the thyroxine molecule, the iodide concentrating tissues only will be selectively irradiated. If radioactive iodine of long half-period is used, thyroxine concentrating tissues will also receive some selective concentration. Only from elements with long half-periods will the selective radiation necessarily conform with the chemical composition of tissues.

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(*a*) Late carcinogenetic effects of the local radiation cannot yet be entirely excluded. No direct evidence supports this possibility and deep x-ray therapy of Graves's disease involved heavy irradiation of neck tissues without carcinogenesis. It is, of course, not necessary to establish whether such a sequel is theoretically possible, but whether it is more probable than death from operation, from thiouracil treatment or from the omission of treatment.

(*b*) Health precautions, electronic equipment, and facilities for measuring and storing radioactive urine are necessary in such treatment and are not generally available.

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Blood changes are not observed, and ovarian or testicular irradiation is almost certainly unimportant in amount.

Radioactive iodine treatment for Graves's disease appears at least to be indicated for post-operative recurrences, in patients with cardiac complications requiring urgent relief, or where thyroidectomy is undesirable from local or general causes, and thiouracil has failed or has not been tolerated. If the fear of late carcinogenesis can be shown to be unfounded, radioactive iodine may become the treatment of choice except in the presence of pressure symptoms, late pregnancy (Chapman and others, 1948) or possible malignancy.

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Radioactive iodine treatment can usefully be undertaken if a thyroid carcinoma is found to concentrate radioactive iodine much more highly than do other body tissues; a ratio of fifty-fold for mean concentrations has been suggested as indicating that treatment may be effective. The tests of iodine uptake by external counting, or by counts or radioautographs on biopsy material, have already been described. In treatment, the highest dose is given which is judged unlikely to cause radiation sickness. This level will depend on the patient's iodine metabolism and in particular on the expected blood concentrations of radioactive iodine, which may be roughly assessed from a preliminary tracer dose. An initial dose of about 100 millicuries is commonly given and causes a moderate and transient depression of leucocytes, particularly lymphocytes. This dose is repeated if tumour activity persists and some cases have received over 2,000 millicuries in the course of several years, many cases being so maintained free of symptoms. In a few cases such dosage has been discontinued without recurrence, and Seidlin has discharged one case as apparently cured seven years after the first treatment. It should be emphasized that radioactive iodine therapy is applicable despite widespread carcinomatosis, provided the tumour concentrates radioactive iodine sufficiently, and provided too great a replacement of liver or other essential tissues has not occurred.

Radioactive phosphorus therapy of polycythaemia

Just as radioactive iodine accumulates in thyroid tissue, so radioactive phosphorus is concentrated in bone, and also in actively dividing tissues in general, and can be used for selective irradiation of the bone marrow in polycythaemia vera. Here, however, the local concentration only exceeds that in other vital organs such as lymph glands by a factor of under five. Some selective concentration of radioactive phosphorus is found in carcinomas, for example of the breast, but it does not normally exceed that in other vital tissues by enough to offer therapeutic advantages.

In polycythaemia, radioactive phosphorus treatment probably allows the most efficient control of the disease. Single doses, usually of 3 to 5 millicuries, cause remission of symptoms and fall of red cell count for periods of about a year in many cases. Patients have now been maintained for many years on repeated dosage, with or without venesection initially (Lawrence, 1949; Friedell and Storaasli, 1949; Doan and others, 1947; Erf, 1946; Reinhard and others, 1946). The irradiation of bone marrow may also cause fall in white cell and platelet count (Hempelmann and others, 1944; Dougherty and Lawrence, 1948), which sometimes follows the dose after a latency of several weeks, so that doses cannot be repeated at short intervals. Occasional instances of thrombocytopenic purpura (Andrews, 1949) have been reported, but this therapy normally gives smooth control of the blood condition.

Radioactive phosphorus has not proved equally effective in other disorders of the blood. In acute leukaemias it is only rarely of any value (Diamond and Warren, 1942; Bayrd and Hall, 1948). In chronic leukaemia (Jacobson and others, 1947) and lymphosarcoma (Jacobson and others, 1947; Kenney, Marinelli and Craver, 1942), it is of about equal value to x-ray therapy with which it may be combined, but it may give helpful results in chronic lymphatic leukaemia (Hahn and Sheppard, 1948; Lawrence, Low-Beer and Carpender, 1949).

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No useful radioactive isotope therapy for Hodgkin's disease has been found, although manganese and other elements (Hahn and Sheppard, 1948; Hoster and others, 1948) in colloidal form given intravenously have had some success in certain cases. Such colloidal radioactive elements have also had moderate success in lymphoid diseases (Sheppard, Goodall and Hahn, 1947). No results of value have been observed on trial of copper or of carbon-labelled stilbamidine in multiple myeloma.

The treatment of osteogenic sarcoma and tumours of bone with radioactive strontium has been attempted (Pecher, 1942), but has not been shown to have any general value. Various "bone-seeking" elements have been identified, but have not been effec- [illegible]

If colloidal materials are injected intravenously, they become concentrated at sites which depend upon the particle size of the suspension, and this observation has suggested a basis for treatment. Small particles are removed rather slowly to bone and liver in experimental animals, whereas larger particles are more rapidly concentrated in reticulo-endothelial cells (Dobson and others, 1949), most of the dose entering liver and spleen, and it has been suggested that carcinoma of the liver might be irradiated by this means. Much larger particles may embolize and remain in the lung capillaries, and Muller and Rossier (1947) have investigated the possibility of treating [illegible]

occasionally even its cure might be attempted. The effects of radioactive iodine in certain types of thyroid neoplasm indicate that the cure of generalized carcinomatosis is not necessarily impracticable.

HEALTH HAZARDS

The risks to health from incorrect handling of radium are familiar. The use of other radioactive elements involves hazards (Quimby and Braestrup, 1950) which are similar in kind but frequently are greater, since the material is not sealed within metal

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If effective methods can be developed for selective radiation of metastases in certain different tissues, the palliative treatment of disseminated cancer will be improved and occasionally even its cure might be attempted. The effects of radioactive iodine in certain types of thyroid neoplasm indicate that the cure of generalized carcinomatosis is not necessarily impracticable.

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Radioactive iodine therapy of thyroid carcinoma

Certain highly differentiated thyroid carcinomas concentrate considerable quantities of iodine in the tumour tissue and metastases (Rawson and Skanse, 1948; Frantz, Quimby and Evans, 1948; Marinelli and others, 1948; Seidlin, Oshry and Yalow, 1948; Rawson and others, 1948; Trunnell, 1949a, 1949b; Paterson, 1950). In other cases, concentration is weaker but still allows the accumulation in tumour tissue of a substantial proportion of a dose of radioactive iodine if all normal thyroid tissue which would compete for the radioactive iodine has previously been removed. Other tumours again are said to acquire, or increase, their capacity to concentrate iodine after a total thyroidectomy. Purely anaplastic tumours are unlikely ever to show significant iodine uptake. It is seen, therefore, that total removal or destruction of the thyroid should be considered except where biopsy reveals an anaplastic carcinoma. For an inoperable growth, the thyroid should be destroyed by heavy radioactive iodine dosage (50 to 100 millicuries), but thyroidectomy is preferable where possible, as allowing earlier tests of iodine uptake in tumour tissue. Both thiouracil and thyrotropic hormone have been used in an attempt to stimulate iodine uptake and it seems likely that the former may have such an effect.

Radioactive iodine treatment can usefully be undertaken if a thyroid carcinoma is found to concentrate radioactive iodine much more highly than do other body tissues; a ratio of fifty-fold for mean concentrations has been suggested as indicating that treatment may be effective. The tests of iodine uptake by external counting, or by counts or radioautographs on biopsy material, have already been described. In treatment, the highest dose is given which is judged unlikely to cause radiation sickness. This level will depend on the patient's iodine metabolism and in particular on the expected blood concentrations of radioactive iodine, which may be roughly assessed from a preliminary tracer dose. An initial dose of about 100 millicuries is commonly given and causes a moderate and transient depression of leucocytes, particularly lymphocytes. This dose is repeated if tumour activity persists and some cases have received over 2,000 millicuries in the course of several years, many cases being so maintained free of symptoms. In a few cases such dosage has been discontinued without recurrence, and Seidlin has discharged one case as apparently cured seven years after the first treatment. It should be emphasized that radioactive iodine therapy is applicable despite widespread carcinomatosis, provided the tumour concentrates radioactive iodine sufficiently, and provided too great a replacement of liver or other essential tissues has not occurred.

Radioactive phosphorus therapy of polycythaemia

Just as radioactive iodine accumulates in thyroid tissue, so radioactive phosphorus is concentrated in bone, and also in actively dividing tissues in general, and can be used for selective irradiation of the bone marrow in polycythaemia vera. Here, however, the local concentration only exceeds that in other vital organs such as lymph glands by a factor of under five. Some selective concentration of radioactive phosphorus is found in carcinomas, for example of the breast, but it does not normally exceed that in other vital tissues by enough to offer therapeutic advantages.

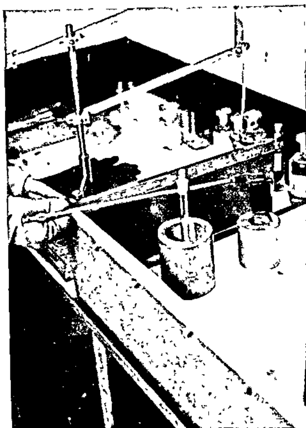




FIG 109.—Stopper removed by long-handled spanner from bottle placed within lead container.

containers, but may be used as a solution, a suspension or even in gaseous form. Dangerous irradiation of parts of the body may result (1) from ingestion or inhalation, (2) from contamination of skin and intense local irradiation, or (3) from exposure of the body too close to an external radiating source for too long.

External radiation

The particular hazards of radiation from a source outside the body will depend both on the radiations of the isotope involved and on its physical state. Certain isotopes such as phosphorus 32 emit *beta* radiation only, so that light shielding of sources will abolish the risk of tissue radiation from an adjacent source. When *gamma* radiation also is emitted, further protection is required either by heavy metal shielding or by maintaining adequate distances between the body and the source during all manipulations.

It is useful during any manipulation that the operator should be aware of the time in which his hands or body would receive a day's allowable dosage if exposed at various distances from the source he is using. For radioactive iodine 131 in amounts ranging from small diagnostic doses to heavy therapeutic ones, allowable times are shown in the Table. It will be seen that for manipulation and calibration of an unshielded 100-millicurie dose, involving say 10 minutes' work, a working distance of 1 foot must be maintained, assuming that no other hazard is encountered during the day. This may be achieved by the use of handling equipment of simple construction (Figs. 108–112), and the regular use of such equipment will minimize chances of external radiation.

TABLE

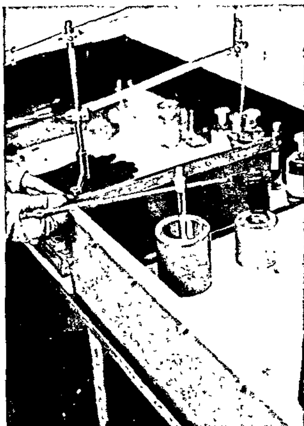
ALLOWABLE TIMES FOR VARIOUS DOSES

Gamma radiation to tissue at a distance of	*I^{131} gives a day's tolerance of 0·05 r with* Dose: 10μc	100μc	1mc	10mc	100mc
¼ inch	45 mins.	4½ mins	27 secs.	2½ secs	¼ sec.
1 inch	12 hrs.	1½ hrs.	7 mins.	40 secs.	4 secs.
3 inches	SAFE	10 hrs.	1 hr.	6¼ mins.	40 secs.
1 foot	SAFE	SAFE	17 hrs.	1¼ hrs.	10 mins.
1 yard	SAFE	SAFE	SAFE	15 hrs.	1¼ hrs.

For injection of hazardous quantities of radioactive elements, further precautions may be needed. In treating bladder carcinomas with radioactive sodium, the large activities and high *gamma* energy involved necessitate heavy shielding and large working distances. For intravenous or other parenteral injections, hazardous amounts of a radioactive element may be either added to an established "drip" or injected from a shielded syringe.

After administration, the dose within the patient may continue to be a significant radiation hazard, particularly to nursing staff, although rarely to adjacent patients. Where much of a large dose is concentrated in one part of the body, it may be necessary temporarily to avoid any washing of overlying areas except what the patient is able to perform himself. Excreta may also require shielding or segregation.

Exposure to external radiation is measured by film badges or small electrometers worn on exposed body areas, the latter having the advantage of indicating at the time that an excessive exposure is occurring. Excessive local exposure of skin may cause flattening and swelling of skin folds, which may be examined regularly by fingerprints in wax. General radiation only causes blood changes at high total dosage.



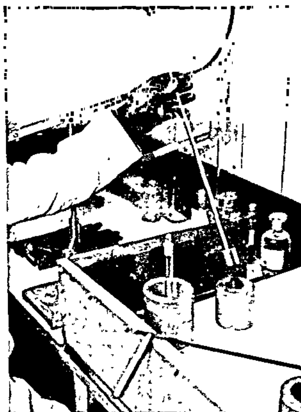


Fig. 109.—Stopper removed by long-handled spanner from bottle placed within lead container.

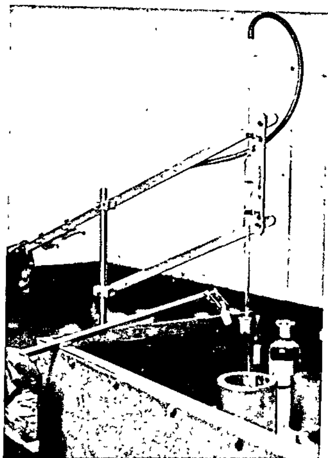


FIG. 110.—Transfer of radioactive iodine solution to flask by syringe-controlled pipette.

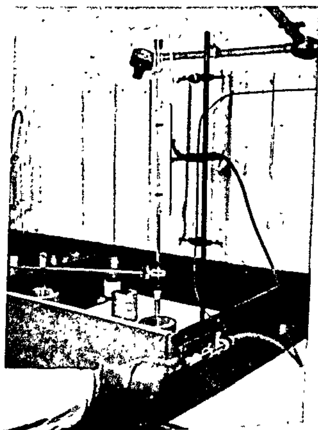


FIG. 111.—Preparation of standard solution from the intended dose by syringe-controlled microburette.

Internal and surface radiation

The general precautions against ingestion and contamination of the skin are usually ... elements in solution. The hazard of

radioactive decay. Carbon 14, strontium, radium, plutonium and many products of

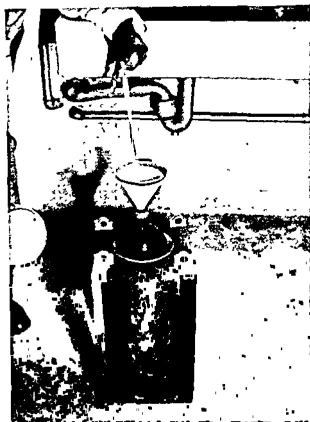


FIG. 112—Collection and preservation of radioactive urine in lead-walled canister.

atomic fission have these dangerous properties, but in work with all radioactive elements the risks of internal radiation require consideration. This is particularly important when the radioactive element is present in dust, vapour or gaseous form, as when carbon dioxide containing radioactive carbon is expired by patients or experimental animals. In these cases, forced ventilation with monitoring of air contamination may be required, and manipulations under fume-cupboard hoods will normally be necessary.

In work with solutions, the main hazards lie in contamination of the hands and consequent ingestion from food or cigarettes. Simple precautions such as the use of rubber gloves and of syringe-controlled pipettes, and the avoidance of eating or smoking in "hot" rooms, may control such risks, or it may be necessary also to monitor hands, shoes or bench areas repeatedly during work. Effective control turns upon a close watch for any form of spilling of active solutions, whether on to benches, the necks or stoppers of containers, rubber seals of ampoules or from receptacles for excreta; and upon efficient cleaning of surfaces on which such spills

occur. The need for remotely controlled manipulation of active solutions increases the likelihood of spills unless equipment is well designed to combine adequate protection with simple and reliable handling. It will always be desirable that a manipulation should become familiar using inert solutions, and then weakly radioactive solutions, before hazardous amounts are used; and the extent of any contamination should be examined repeatedly before an operation is adopted.

The amount of material actually ingested, despite such precautions, should also be monitored whenever possible, by examination of excreta, or external counting on staff. With radioactive iodine, for example, weekly *gamma* radiation counting over the thyroid will rapidly detect retention of amounts giving less than 0·005 röntgens per day in the thyroid, and, therefore, offers efficient warning of any approach towards maximum permissible levels.

A further control of prolonged and excessive general body radiation is obtained from the blood count. With conventional examinations this test is insensitive, and the interpretation of finer changes is not yet clarified. It should be made at least 3-monthly in all workers using radioactive materials in the wards or laboratories as a check upon unsuspected failure of the more delicate monitoring methods. The latter should, however, constantly be used and developed, if the clinical value of radioactive elements is not to be offset by serious hazards to patients and staff using them.

(*See also British Surgical Practice:* Radioactive Isotopes, Vol. 7, page 262, S. Key 285.)

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STRESS INCONTINENCE

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INTRODUCTION

The term stress incontinence, coined by Eardley Holland (Bonney, 1943) designates the type of urinary incontinence which occurs when the intra-abdominal pressure is raised suddenly, such as when lifting heavy weights, coughing or laughing.

The importance of the problem and of its unsolved state is attested by the sizeable literature which has appeared about it, and also by the numerous operations which have been devised by ingenious gynaecologists and urologists for its relief. At least twenty-three different sling operations have been promulgated since 1919, but this number appears inconsiderable beside the multiplicity of vaginal plastic procedures which have been used over the past years.

CLINICAL FINDINGS

Clinically it has been found in patients complaining of stress incontinence that the urethra and bladder are displaced downward and forward, that the external urethral meatus is patulous and that stress incontinence can be demonstrated during the examination. The bulk of evidence shows, and the majority of authorities agree, that this displacement of the urethra and bladder neck is the primary lesion in stress incontinence. Millin and Read (1948) demonstrated this descent of the bladder neck in a series of cystographic studies. How this descent interferes with the urethral sphincteric mechanism is not known. Dilatation of the urethra, funnelling of the proximal third and loss of the normal anterior curvature of the urethra have been found occasionally associated with this distressing symptom.

REPAIR OF DEFECTS IN THE URETHRAL SUPPORTS

[illegible] the originators' conception of the defects in the urethral supports, a description of these will be found helpful.

Between Colles's fascia and the inferior layer of the urogenital diaphragm lie the ischio-cavernosus and bulbo-cavernosus muscles (Figs. 113 and 114). The bulbo- [illegible] rigid support to the prolapsed urethra to prevent stress incontinence.

Beneath this superficial perineal space lie the two layers of urogenital diaphragm. Ruaramo (1946), modifying the procedure of Berkow, utilizes the urogenital diaphragm to support the urethra. An incision is made in the vestibule from the

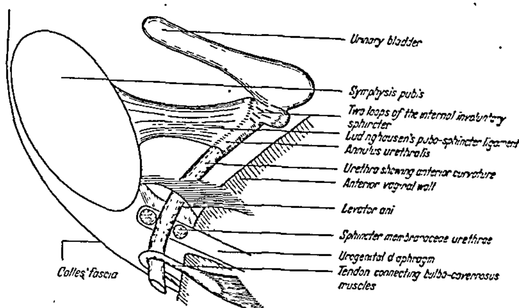


Fig. 113.—Diagram of a normal urethra and its sphincters.

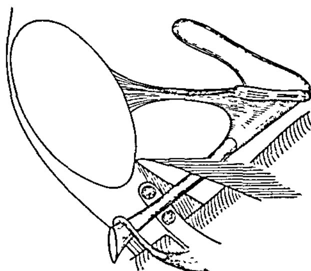


Fig. 114.—Diagram of a prolapsed urethra, showing patulous meatus, dilatation and funnelling of the urethra and loss of normal anterior curvature.

clitoris to the external meatus and extending into the vagina. The distal portion of the urethra is then mobilized and is transplanted to a much higher position beneath the clitoris, where it is fixed. The muscles of the urogenital diaphragm are then sutured beneath it. He claimed satisfactory results in a few cases, but the operation probably acts by increasing the resistance to the outflow of urine and hence would be suitable only for mild cases of stress incontinence. Between the two layers of the urogenital diaphragm lies the deep transverse perineal muscle, the fibres of which are concentrated around the urethra as a voluntary sphincter, the sphincter membranaceae urethrae (Davies, 1942). It would seem that if the external voluntary sphincters are functioning normally, and if the involuntary sphincter is damaged, urine may then run into the

urethra and be held there, thus producing urge incontinence, a symptom commonly found in association with stress incontinence.

Immediately beneath the urogenital diaphragm lie the muscles of the pelvic diaphragm. Of the levator group the pubococcygeus muscles are most important. As they pass posteriorly they send a definite bundle of fibres to each side of the urethra at about its middle third. *At times they completely surround the urethra, though* Kennedy (1937 and 1941) denies this. Besides constricting the urethra circumferentially the simultaneous contraction of both levators angulates it anteriorly (Davies, 1942). The levator-plasty operations of Franz and of Wagner consist of taking strips of muscular tissue from the levators as they pass on either side of the urethra and then bringing them under and around the urethra. These were not a success as they only supported the middle third of the urethra leaving the neck of the bladder, the most important part, unsupported.

Pacey (1949) combines a careful fascial repair of the other supporting structures of the urethra with an approximation of the medial borders of the levator muscles between the urethra and the vagina. Read (1950) advocates this as the vaginal proce- [illegible] incontinence.

[illegible] which is formed by a [illegible] bladder; these run in opposite directions, pursuing a similar course in the sphincter. The fibres are collected *into two loops (Ludinghausen, 1932), one of which surrounds the urethra anteriorly* and laterally, the other surrounding it posteriorly and laterally, and so when they contract they narrow the lumen down to a transverse slit. Then, to complete the closure, the urethral mucous membrane, due to the presence of venous plexuses in the submucosa, is approximated as a soft yielding cushion (*Heiss, 1915*).

The female urethra is completely surrounded by striated muscle only along its [illegible] 1900). There is no involuntary external sphincter around the urethra (Best and Taylor, 1945).

At the beginning of the act of micturition, the longitudinal diameter of the bladder increases and, at the same time, the floor of the bladder descends downwards and posteriorly. This increases the distance between the symphysis pubis and the bladder neck and hence the fibromuscular ligaments running from the posterior surface of the symphysis pubis and radiating into the vertex of the detrusor loop and into the annulus urethralis are put on the stretch and so exert a lateral and forward dilating traction upon this portion of the sphincter, thus opening it (Heiss, 1915). This hypothesis, if correct, logically explains the cause of stress incontinence as, when the urethra and bladder neck are prolapsed downwards and forwards, this sphincter would be permanently open or so weakened that any sudden increase in intra-abdominal pressure would be sufficient to force urine past it. The post-operative retention and difficulty with micturition experienced by a patient whose urethra has been raised and replaced *in its proper position behind the symphysis pubis corroborates this hypo-*thesis as, instead of being too tense, the fibromuscular ligaments extending into the urethral sphincter are too loose and so will not permit its proper function until they regain their tonus.

Kelly (1913) *was the foremost protagonist* of damage to the vesical sphincter resulting from birth trauma as the primary cause of stress incontinence. He stated: ". . . the key to the successful treatment of stress incontinence lies at the internal urethral orifice and in the sphincter which controls the canal at this point." The *operation he devised*, now universally known as the Kelly stitch (Fig. 115) consists of resuturing together the torn ends of the damaged internal sphincter. This operation

had many enthusiastic followers, including Fulkerson (1939) and Furniss (1924), all three claimed a 100 per cent cure rate. Recent literature, however, indi that this operation fails in 15–40 per cent of cases as it fails to elevate the bla neck.

An extensive investigation was conducted by Kennedy (1937) into the intr musculature of the urethra, and he found major alterations in the contour o structure. He believes that, as a result of birth trauma, adhesions form around damaged urethra and, by contraction, pull on the circular fibres of the involun urethral sphincter, prevent their proper apposition, thus decreasing urethral resistà

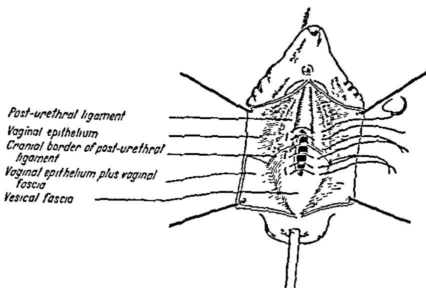


FIG. 115.—Kelly's stitch.

A wide mobilization of the urethra and bladder from the surrounding structures form the basis of his extensive plastic repair operation, the latter parts of which aim a elevation and fixation of the urethra and bladder neck in their normal retropubi positions.

Geist and his co-workers (1943) have called attention to the fact that urinary in continence may result from prolonged oestrogen deficiency which causes impaired tonus in the involuntary sphincter. In a group of patients showing evidence of oestro gen deficiency, they obtained a 75 per cent cure rate following an intensive course of oestrogen therapy, but withdrawal of the oestrogens resulted in a recurrence in every case after periods ranging from 7 weeks to 4 months.

Peham and Amreich (1934a) showed that the ground bundles of the endopelvic fascial system lie on the upper surface of the levator ani muscles to which they are intimately attached. From this region the fascia passes upwards to envelop the vagina, urethra, bladder and uterus and from these organs it passes laterally and also posteriorly to the side walls of the pelvis, forming their direct supports. These endopelvic fascial ligaments consist partly of muscular elements and partly of fibrous tissue.

Operations on the post-urethral ligament

In the region of the neck of the bladder, the vaginal endopelvic fascia fuses with the vesical fascia to form the post-urethral ligament (Shaw, 1947). The cranial border of this ligament (Fig. 116) is attached to the base of the bladder in the region of the internal sphincter and passes downwards parallel to the vagina, to which it is also attached, to

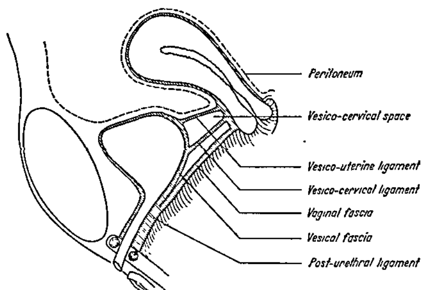


FIG. 116.—Diagram of endopelvic fascial supports of urethra and adjacent structures.

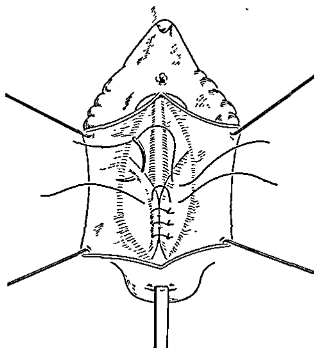


FIG. 117.—Diagram showing para-urethral and vesical supporting structures being reefed.

be inserted into the superior border of the genital orifice in the urogenital diaphragm. The lateral attachments are to the pubic rami. The urethra traverses this ligament along its whole course and, when the post-urethral ligament is undamaged, it prevents a downward displacement of this structure. It is on this ligament that modern gynaecologists concentrate their energies in performing their various methods of urethroplasty (Fig. 117). The initial steps of these operations do not vary, consisting of a central

The advantages of this operation are that the anterior vaginal wall is opened and other anatomical defects such as cystocele might be repaired at the same time; the sling is placed in its correct position beneath the urethra at its junction with the bladder and the effects of the degree of tension on the urethra and other structures can be gauged visually. An obvious disadvantage is that it is a combined approach necessitating rather long abdominal incisions and difficulties are encountered in patients who have had previous abdominal operations.

The use of a narrow band of fascia as a sling has been found by experience to be a dangerous procedure, as localized pressure on such a weak structure as the urethra produces sloughing or stricture formation with their attendant dangers such as fistulae and renal complications. The direction of pull is also incorrect since, to replace the urethra in its normal position behind the symphysis pubis, it must be towards the pubic bone, not above it.

The Millin-Read operation

The Millin-Read sling operation is an abdominal approach to the problem (Millin, 1947). Narrow strips of fascia, 20 centimetres long, are resected from the aponeurosis of the external oblique muscles so that their fixed ends are still attached to the latter. Following on wide exposure of the cave of Retzius, the strips are introduced under the bladder neck by passing the Millin fascia introducer between the urethra and vagina from above. Having drawn the urethra upwards, the strips of fascia are sutured together. Read (1950) has published the results of 126 such operations with 91 absolute cures, 21 partial failures and 13 complete failures. There was one post-operative death due to pulmonary embolism.

This operation, unless performed by a very competent surgeon, although theoretically sound, is fraught with dangers, as the sling, a narrow band, when passed under the urethra involves blind or semi-blind dissection. Since there is no normal plane of cleavage between the urethra and vagina, the former is frequently damaged while the Millin fascia introducer is being passed. Temporary and at times permanent fistulae are not uncommon complications. From this approach it is difficult to apply the correct degree of tension on the sling and cases of complete severance of the urethra have been reported. Owing to the technical difficulties of the approach, the sling is often not placed under the neck of the bladder, but under some other portion of the urethra, thereby kinking it, and this has led, in some cases, to complete retention of urine.

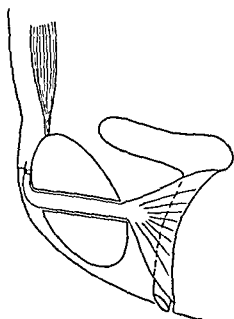


FIG. 120.—Diagram showing direction of pull of Shaw's sling.

Shaw's sling

Shaw's (1949) sling is basically a vaginal approach to the problem. A spindle-shaped strip of fascia lata, 6 inches long and 1½ inches wide at its widest part, is taken from the lower end of the fascia lata in the thigh. The vagina is incised, as described previously, and the urethra and bladder neck are exposed, leaving a small cuff of vaginal skin near the external meatus to which one of the short ends of the sling is sutured, the other being sutured to the post-urethral ligament and vaginal fascia immediately under the internal sphincter and on either side of it. The cave of Retzius

is then entered by deliberate incision on either side of the urethra near the pubic rami. Then, through small skin incisions, the pubic bone is exposed and two drill holes are made immediately lateral to the symphysis pubis midway between the superior and inferior borders. Using next a curved instrument which is passed through these drill holes the long ends of the sling are drawn through the bone and sutured to the periosteum, thus elevating and fixing the urethra and bladder neck. This sling operation has been performed 105 times with one failure.

The excellent results achieved by this operation are due, firstly, to the type of sling used and, secondly, to the direction in which it pulls. The broad band is placed in [illegible]

follows that of Ludinghausen's pubo-sphincteric ligament. Being a spindle-shaped sling, the main traction lines of force pass through its centre and, when applied to the urethra, restores its normal curvature (Fig. 120). Since the supporting ligaments of the urethra act mainly on the lateral walls and particularly so if they are damaged or torn beneath the urethra, they exert a lateral dilating traction upon it, causing dilatation. During this operation these ligaments are incised to gain access to the cave of Retzius, so relieving this abnormal traction, their place being taken by the supporting sling.

SUMMARY

The position at the moment may be summarized as follows:

(1) The cause of stress incontinence is unknown

(2) Operative treatment should aim at the elevation and fixation of the urethra and bladder neck in their normal retropubic positions.

(3) Approximately 90 per cent can be relieved by vaginal procedures such as Shaw's or Pacey's urethroplasties.

(4) Sling operations, reserved at the moment for the more difficult cases, would appear to be the answer to the problem.

See also British Surgical Practice Pelvic Organs—Displacement, Vol. 6, page 478.)

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ABDOMINAL EMERGENCIES

See also B S.P., Vol. 1, p. 1, S. Key 1.

Perforation of the intestinal tract

[illegible]

on record. Most of the cases have been [illegible]

[illegible]

the injury before symptoms manifest [illegible]

[illegible] ...tion of peristalsis and the [illegible]

[illegible]

showed a tear one inch long, on the anti-mesenteric border of the ileum, 18 inches from the ileo-caecal valve. This was closed and the patient made an uninterrupted recovery.

Perforation of the rectum.—Perforation of the rectum is discussed by Jones (1949). [illegible]

[illegible]

[illegible] cases reported in the literature, which occurred in pregnant women at term or in elderly people [illegible]

3 c [illegible]

[illegible]

of [illegible]

per [illegible]

Inflammatory conditions

Primary inflammation of the appendices epiploicae [illegible]
literature on primary inflamma [illegible]
cases. They present only cases in [illegible]

were due to primary disease of these appendices. Fifty-eight cases have been found. No explanation has ever been offered as to why the appendices should ever be the site of a primary inflammation, but most authors believe that torsion of the pedicle is usually the direct cause even when torsion cannot be demonstrated.

30 years of age and 50 years, and the male-to-female ratio was 36: 22. Pain and tenderness were the most constant findings and nausea, vomiting or rigidity occurred in about half the cases. Rebound tenderness or a palpable mass was only occasionally present. These 6 reported cases occurred within 10 years at Baylor Hospital. In no instance was torsion

one to suspect the condition.

Flavell, G. (1949), *Lancet*, **1**, 649.
Jones, J. D. T. (1949). *Brit. med. J.*, **1**, 933.
Marinis, T. P., and Cheek, J. H. (1949). *Ann. Surg.*, **28**, 533.

ABDOMINAL PAIN

See also B S P., Vol. **1**, p. 13, S. Key 2.

Mesenteric cyst

around the cyst and a belt of resonance across it. The final diagnosis depends on the

was done in the case reported. Marsupialization is only rarely indicated, and aspiration is merely a preliminary to operative removal. The mortality of mesenteric cyst is estimated at 25–35 per cent.

Blackman, R. L. (1949). *Amer. J. Surg.*, **77**, 371.

ADRENAL GLANDS

See also B S.P., Vol. **1**, p. 94, S. Key 12.

Tumours of the adrenal medulla

Phaeochromocytoma: bilateral case and new diagnostic tests.—REID and SALM (1949) give a detailed report on a woman aged 40 years, suffering from phaeochromocytoma

intervention.

Reid, T. M., and Salm, R. (1949). *Brit. med. J.*, 1, 1116.

ANAESTHESIA, SPINAL

See also B S.P., Vol. 1, p. 245, S. Key 29.

Caudal analgesia

close co-operation between him and the obstetrician. In recent years the proportion of women at this hospital judged suitable for caudal analgesia has risen from 40 per cent to 90 per cent. The remaining 10 per cent were judged unsuitable because of quick and easy labour, sacral deformities, obesity or local infection of the caudal area. Many of the failures recorded in this series occurred in women who had previously had caudal analgesia.

after the initial test dose of 8 millilitres of the 1·5 per cent Metycaine solution, are signs of inadvertent subarachnoid injection which must be watched for. The remainder of the first

Herzlich, J. (1949), *N.Y. St. J. Med.*, 49, 1531.

APPENDICITIS

See also B S.P., Vol. 1, p 293, S. Key 35.

Aetiology

Analysis of 2,35
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performed, on
in incidence o
to the disease
has not yet b
incidence of

were due to primary disease of these appendices. Fifty-eight cases have been found. No explanation has ever been offered as to why the appendices should ever be the site of a primary inflammation, but most authors believe that torsion of the pedicle is usually the direct cause even
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the diseased appen
remaining cases th
30 years of age and 50 years, and the male-to-female ratio
were the most constant findings an
cases. Rebound tenderness or a
reported cases occurred within 10

one to suspect the condition.

Flavell, G. (1949), *Lancet*, 1, 649.
Jones, J. D. T. (1949) *Brit. med. J.*, 1, 933.
Marinis, T. P., and Cheek, J. H. (1949). *Ann. Surg.*, 28, 533.

ABDOMINAL PAIN

See also B S P., Vol. 1, p. 13, S. Key 2.

Mesenteric cyst

other abdominal cystic tumours. Another feature is the presence of a zone of resonance around the cyst and a belt of resonance across it. The final diagnosis depends on the

was done in the case reported. Marsupialization is only rarely indicated, and aspiration is merely a preliminary to operative removal. The mortality of mesenteric cyst is estimated at 25–35 per cent.

Blackman, R. L. (1949). *Amer. J. Surg.*, 77, 371.

ADRENAL GLANDS

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Tumours of the adrenal medulla

Phaeochromocytoma: bilateral case and new diagnostic tests.—Reid and Salm (1949)

intervention.

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Herzlich, J (1949), *N.Y. St. J. Med*, 49, 1531.

APPENDICITIS

See also B.S.P., Vol 1, p. 293, S Key 35.

Aetiology

were due to primary disease of these appendices. Fifty-eight cases have been found. No explanation has ever been offered as to why the appendices
primary inflammation, but most a
direct cause even when torsion car
present has been due to thrombos

various parts of the colon. Most patients were between 30 years of age and 50 years, and the male-to-female *ratio was 36 : 22.* Pain and tenderness were the most constant findings and nausea, vomiting or rigidity occurred in about half the cases. Rebound tenderness or a palpable mass was only occasionally present. These 6 reported cases occurred within 10 years at Baylor *Hospital. In no instance* was torsion demonstrated. In all
although in one case
localized to this quad
others. Rigidity was
that in any acute surgical abdomen in which primary disease cannot be demonstrated elsewhere, one should remember and explore thoroughly for the presence of a diseased appendix epiploica. And they suggest that shifting tenderness on clinical examination should cause one to suspect the condition.

Flavell, G. (1949), *Lancet*, 1, 649.
Jones, J. D. T. (1949). *Brit med J.*, 1, 933.
Marinis, T. P., and Cheek, J H (1949). *Ann. Surg.*, 28, 533.

ABDOMINAL PAIN

See also B.S.P., Vol. 1, p. 13, S. Key 2.

Mesenteric cyst

Aetiology and treatment.—BLACKMAN (1949) reports a case of mesenteric cyst in a female aged 54 years which was diagnosed correctly before operation. Mesenteric cyst was first

lining. There are no specific symptoms. The outstanding features of the tumours are their great mobility and the presence of intermittent pain of greater severity than is common with other abdominal cystic tumours. Another feature is the presence of a zone of resonance around the cyst and a belt of resonance across it. The final diagnosis depends on the elimination of more common intra-abdominal conditions but is not usually made before operation. Treatment is surgical and enucleation is the method of choice whenever it can be

25–35 per cent.

Blackman, R. L. (1949). *Amer. J. Surg.*, 77, 371.

ADRENAL GLANDS

See also B.S.P., Vol. 1, p. 94, S. Key 12.

Tumours of the adrenal medulla

. . . at necropsy a further tumour weighing 40 grammes was found at
, comparatively rare tumour;
. . . only 16 cases

intervention

Reid, T. M , and Salm, R. (1949) *Brit. med. J.*, **1**, 1116.

ANAESTHESIA, SPINAL

See also B S P., Vol. 1, p 245, S Key 29.

Caudal analgesia

. . . 12,000 *deliveries*.—HERZLICH (1949) reports on
years,
rained
nstant
ust be
ion of
ent to
d easy
. . . deformities, obesity or local infection of the caudal area Many of the failures

Herzlich, J. (1949), *N Y St. J. Med.*, 49, 1531.

APPENDICITIS

See also B S P , Vol. 1, p 293, S. Key 35.

Aetiology

were due to primary disease of these appendices. Fifty-eight cases have been found. No explanation has ever been offered as to why the appendices should ever be the site of a primary inflammation, but most authors believe that torsion of the pedicle is usually the

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Jones, J. D. T. (1949) *Brit. med. J.*, 1, 933.
Marinis, T. P., and Cheek, J. H. (1949). *Ann. Surg.*, 28, 533.

ABDOMINAL PAIN

See also B S.P., Vol. 1, p. 13, S. Key 2.

Mesenteric cyst

around the cyst and a belt of resonance across it. The final diagnosis depends on the

25–35 per cent.

Blackman, R. L. (1949). *Amer. J. Surg.*, 77, 371.

ADRENAL GLANDS

See also B S P., Vol. 1, p. 94, S. Key 12.

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Phaeochromocytoma: bilateral case and new diagnostic tests.—Reid and Salm (1949)

intervention

Reid, T. M., and Salm, R. (1949). *Brit. med. J*, 1, 1116

ANAESTHESIA, SPINAL

See also B S P, Vol. 1, p 245, S. Key 29.

Caudal analgesia

Herzlich, J. (1949), *N.Y. St. J. Med*, 49, 1531.

APPENDICITIS

See also B S P., Vol. 1, p. 293, S Key 35.

Aetiology

during the whole period under discussion. In contrast with the
females were shown
may influence these
genital inflammation
citis, it would appear
that it occurs more frequently in males.

Finger, J. (1949). *Med. Klin.*, 44, 1017.

ARTERIES

See also B.S.P., Vol. 1, p. 327, S. Key 37.

Ligation of arteries

can largely be avoided by ligating the common rather than the internal carotid artery, and by section of the artery rather than tying it in continuity. Experience has convinced the author of the safety of this procedure in persons who are reasonably fit and who satisfy the tolerance test. In a series of 19 personal

encephalography at the time of occlusion makes it clear that this procedure increases cerebral anoxia. Tolerance tests are carried out to ascertain the competence of the circle of Willis to provide an anastomosis (as described by the author in 1947) and to give rise to a collateral blood-supply. The common carotid artery is exposed and temporarily occluded. The patient's reactions are noted; dynamometer readings are taken at 3-minute intervals from the opposite hand, and the cerebral activity is recorded by electroencephalography. If no untoward reaction occurs within 15–20 minutes, the artery is divided between silk ligatures and the wound is closed. Division of a common carotid artery reduces to about one-half the

Embolism

Aetiology of peripheral arterial embolism.—Iselin and de Balsac (1949) present a new

study of the whole arterial system *post mortem*, has emboldened them to put forward

suggests that the clot is not of migratory origin. In 1 of these 5 cases post mortem

main trunk pulsated. Finally, good clinical results of operation depend not on the operation performed or on whether or not a flow of blood is obtained, but on whether arterial pulsation reappears or remains absent

Prophylactic auricular resection for recurrent arterial embolism.—Resection of the left auricular appendix, as a prophylaxis for recurrent arterial embolism, is discussed by MADDEN (1949). Embolism occurs in about 45 per cent of cases of rheumatic mitral stenosis—one of the most common causative conditions—originating as a mural thrombus within the left auricle or its appendix, more commonly the latter. This fact led Dock in 1946 to suggest resection of the left auricular appendix in cases of rheumatic heart disease with mitral

later but, although there was apparent improvement for the first week, the patient died

embolic occlusions of peripheral arteries.

Contusion

Diagnosis and treatment of acute arterial injuries.—Acute arterial injuries are discussed by FREEMAN (1949). Such injuries are not necessarily caused by an open wound, but may

haemorrhage (2) In cases of partial division, there may be secondary haemorrhage with,

properties of smooth muscle, may occur even if the vessels have not been touched. (4) Compression of an artery is a serious lesion and is found mainly around the elbow or knee Loss of arterial continuity is particularly serious near the joints of the extremities

forceps should not be applied to an

stated that

Treatmen

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should be avoided, and circular plaster encasement should not be used in fractures in the presence of impaired circulation. Sympathetic nerve block may help to relieve peripheral vasospasm. Any definitive treatment should be delayed for 2–3 months, unless there are urgent indications for intervention, such as secondary haemorrhage, or paralysis and increasing anaesthesia of the distal parts of the limb.

Tumours

Bilateral carotid tumour.—KLINE, THOMAS and MCNAMARA (1949) report on a case of

extraction of 12 teeth in 1932, and in 1943 another swelling arose on the right. One year before hospitalization both swellings became so large that he sought advice. There was no family history of tuberculosis or glandular enlargement. Except for a recent squamous carcinoma of the lower lip, which was considered to be unconnected with the neck tumours, he was healthy. The right tumour lay below the angle of the jaw and under the sternomastoid muscle, and the surface area was some 8 × 4 centimetres. The mass on the left was similar but slightly smaller. Pre-operatively the patient had 13 teeth extracted, and deep x-ray

involving the internal carotid artery and vagus nerve. Sections taken from each tumour showed new growth of polyhedral elongated cells, surrounded by vascular spaces lined with endothelial cells.

Cirsoid aneurysm of the scalp.—A case of cirsoid aneurysm of the scalp is reported on by GRIMES and FREEMAN (1949). A male patient, aged 35 years, had sustained a scalp laceration,

caused

symptc

in the

gressive, result from non-penetrating trauma to an area containing a congenital angioma-us lesion. They are distinguished from the more common congenital angioma by the pulsation,

Aneurysm

Ligation of abdominal aorta for aneurysm.—PRUDENTE (1949) reports on a successful case of ligation of the abdominal aorta for aneurysm by the spiral method, and describes how he checked the progress of the case by aortography. Since Sir Astley Cooper first ligated

tape, and his patient survived 2 years 1 month; when the patient finally died, the autopsy

reactions were negative. Operation under spinal analgesia was performed on 30 August,

put around the aorta above the aneurysm and, on being tightened, was found to stop pulsa-
5 centimetres wide, was
about 2·5 centimetres
raphy was performed,
al blood supply. The
patient was then discharged, being free from pain and able to walk unaided. Three and a half years after operation the patient was symptomless. The author concludes that aneurysm of the abdominal aorta can be cured by proximal occlusion, and that temporary disability of locomotion, due to neurotrophic changes, will gradually disappear.

Intrasaccular endo-aneurysmorrhaphy for aneurysm of left subclavian vessels—PETROV (1949) describes a successful intrasaccular endo-aneurysmorrhaphy, performed by him in 1945 in an extremely rare case of arteriovenous endoscalenic aneurysm of the left sub-

pectoralis major was cut 1 centimetre from the clavicular insertion, and the clavicle was resected at its outer third, disarticulated at its inner end, and retracted upwards. The internal jugular, subclavian and axillary veins were found to be involved in a sclerosed lump. The dissection of the axillary vessels could only be performed after resection of the left half of the sternum and the first rib. All venous communications with the tumour were then ligated and divided, and arterial clamps were placed proximally and distally on the subclavian artery. The tumour was opened, an orifice communicating with the subclavian artery was sutured, and the walls of the sac were sewn over the suture line. When clamps were removed no bleeding occurred, while the artery refilled but did not pulsate. This operation took 7 hours. Five months later the patient had recovered all movements of his arm and the radial pulse had reappeared Two years later the same state of affairs was maintained.

Freeman, N. E. (1949). *J. Amer. med Ass.*, 139, 1125.
28
er. J. Surg., 77, 120.
Prudente, A. (1949). *Amer. J. Surg.*, 77, 79.
Rogers, L. (1949). *Lancet*, 1, 949.

ARTHRITIS

See also B.S P , Vol. 1, p. 371, S Key 38.

at any theory of

can be related to the hyperaemia of the spinal meninges, secondary to the intense activity in the adjacent joints and the vertebral bone. The disease appears to have an incidence of about 1:2,000 of the general population "at risk", and 10 males are affected to 1 female. Of the 100 patients studied, there were 10 who knew so little of their families that the recording of their histories was considered as worthless. The remaining 90 came from 83 families. In these, there were 10 secondary cases in brothers and sisters. The incidence of multiple cases within sibships was thus approximately 11 per cent, which is 100 times greater than would be expected, assuming a random distribution. Thus confirmation is provided of the findings of Clausen and Kober in 1936 and Rogoff and Freyberg in 1948, that heredity plays a major role in the aetiology of the disease.

West, H. F. (1949). *Ann. rheum. Dis.*, 8, 143.

AUTONOMIC NERVOUS SYSTEM—INTRODUCTION

See also B.S.P., Vol. 1, p. 46, S Key 43.

Sympathetic and parasympathetic systems

Clinical manifestations of autonomic dysfunction.—LYONS and CALIVA (1950) summarize the clinical manifestatio[illegible] autonomic system as a [illegible] bodily activity to envi[illegible]

[illegible]

a powerful and convincing array [illegible]

its fundamental functional activities; these can be recognized as the chemical phase of nervous activity. The fundamental concept of autonomic function is that it acts as an accelerator of organ integration, and that it retains in its functional expression certain older biological mechanisms, which, in more primitive forms, are operated by tissue metabolites or hormones. These nervous-tissue-produced chemical substances appear to be the mechanism by which a stimulus is conveyed from a nerve to an effector organ.

Lyons, R. H., and Caliva, F. S. (1950). *N Y. St. J. Med*, 50, 1801.
Reid, L. C. (1950). *N.Y St. J Med.*, 50, 1797.

AUTONOMIC NERVOUS SYSTEM—ARTERIES

See also B.S.P., Vol. 1, p. 466, S. Key 45.

Operative procedures

Indications for and results of surgery.—RAY (1950) discusses surgery of the autonomic nervous system, its indications and results Sympathetic denervation has a much wider application than the surgery of the parasympathetic system, which is virtually confined to vagotomy for peptic ulcer. In Raynaud's disease, interruption of sympathetic supply to the involved part is often beneficial The earlier the operation the better are the results. It is [illegible]

2 to 5 per cent of patients with peripheral nerve injuries caused by penetrating wounds The re[illegible]
In ang[illegible]
promis[illegible]
parave[illegible]
Usually the bilateral operation is required. In chronic pancreatitis, the choice may lie [illegible]
p[illegible]
f[illegible]
c[illegible]
thectomy. He concludes by stressing the necessity for the periodical individual and collective evaluation of results.

Ray, B. S. (1950). *N.Y. St. J. Med*, 50, 1810.

BLADDER INFECTIONS

See also B.S.P., Vol. 2, p. 103, S. Key 54.

Aetiology and treatment

Use of liquid paraffin in removing light foreign bodies from the bladder.—LANE (1949) [illegible]

Lane, T. J. D. (1949) *Brit. med. J.*, 2, 216.

Of the 100 patients studied, there were 10 who knew so little of their families that the recording of their histories was considered as worthless. The remaining 90 came from 83 families. In these, there were 10 secondary cases in brothers and sisters. The incidence of multiple cases within sibships was thus approximately 11 per cent, which is 100 times greater than would be expected, assuming a random distribution. Thus confirmation is provided of the findings of Clausen and Kober in 1936 and Rogoff and Freyberg in 1948, that heredity plays a major role in the aetiology of the disease.

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AUTONOMIC NERVOUS SYSTEM—INTRODUCTION

See also B.S P., Vol. 1, p 46, S. Key 43.

Sympathetic and parasympathetic systems

Clinical manifestation
the clinical manifestatio
autonomic system as a
bodily activity to envi

response to a physiological emergency, may result from adrenaline secretion ... the authors postulate
...e which
...ses and

...he author's
...pported by
...ion appears
...assessment
...volution of
...Intosh and
Feldberg, which has done much to substantiate this concept. That the nervous system
... Sherrington lists three mechanisms
...system. At the
...ions by larger
...tial capacities

renal arteriolar degeneration. The author's observations are related to a series of more than 30 cases so treated without mortality. The operation was performed in 2 stages, with 3 months' interval between each stage. Four-fifths of the adrenal gland was removed at

Pre-ganglionic sympathectomy in hypertension.—Referring to earlier reports that benefit may be derived from preganglionic sympathectomy in cases of arterial hypertension, MAITLAND (1950) records the results of his investigation of 7 such patients, to determine the part played by redistribution of the blood flow within the kidney. Pre-operative intravenous pyelography showed no abnormality in 4 cases, chronic renal infection in 1 case

clearance in the denervated kidney improved in
case was considered to have improved similar
increase in urinary volume in 3 of the cases
roughly in proportion to the temporary fall
phrectomy instead
of perative improve-
me The author does
may indicate an
e kidney In each
r after operation,
with evidence of
satisfactory secretion from the opposite organ.

Results of sympathectomy in hypertension—The effect of sympathectomy on blood

ectomy eventually adopted as a standard extended from the eighth thoracic to the first lumbar ganglion. There were 187 female patients of an average age of 39 6 years, and 105 males of an average age of 40 2 years, the age and sex incidence showing a marked constancy throughout the series. Operation was performed, in the great majority of cases, for essential hypertension It is interesting to note that papilloedema was observed in 20 per cent of cases in group 1, 14 per cent in group 2 and 18 per cent in group 3. Comprehensive follow-up examinations have been made of 98 per cent of the 219 patients who survived the operation; 100 cases were followed up at 5 years after the operation The results showed that at the end of 5 years the blood

reduced significantl
not significantly lo
these results with th
to become less favo

BLOOD AND BLOOD-FORMING ORGANS: BLOOD EXAMINATION

See also B S P., Vol. 2, p. 159, S. Key 60.

The anaemias

oxygen environment. In about 3 per cent of individuals with the sickle-cell trait, sickle-cell anaemia develops. The disease usually manifests itself in infancy, but it varies in both

tissue. The spleen, bones and central nervous system are commonly involved, and less commonly the kidney, liver, spleen and intestinal tract. The acute abdominal pain may ... *ussusception, intestinal obstruction, acute appendicitis,* ... The bone and joint pains have been confused with ... tain marked bony changes are sometimes found. There may be thickening of the vault of the skull, with perpendicular trabeculations of a "hair-on-end" appearance. Aseptic necrosis, foll... been observed. The legs of adults are particula... cases are presented. In some cases the abdomen ... cell anaemia had been made. In others, despite ... necessary to open the abdomen as a precaution. In a case of supposed ureteric calculus, a renal infarct was found.

Wilson, H., Patterson, R. H., and Diggs, L. W. (1950). *Ann. Surg.*, 131, 641.

BLOOD PRESSURE: HIGH AND LOW

See also B.S.P., Vol. 2, p. 189, S Key 61.

High blood pressure

... is made of the value ... Keith, Wagener and Barker of the Mayo Clinic, ... 5–9 years; the mortality in the ... r, Loofbourow and Doering, ... 30 cases followed up for an ... 2 to 94 per cent. It is pointed out that only 2 papers have dealt with the results of surgical intervention in adequate numbers of cases followed up for 5–10 or more years; one is by Peet and Isberg, and the other by Smithwick and his associates Comparing the respective grades of patients, it is ... but that other patients have benefited ... nct in the manage- ... respond better to ... ted by denervation ... s from the eighth ... anchnic nerves. If ... e twelfth thoracic ..., removal from the ... rves, seems to be ... of hyper- ... to ... the ... of

renal arteriolar degeneration. The author's observations are related to a series of more than 30 cases so treated without mortality. The operation was performed in 2 stages, with

[illegible]

nicectomy. In 1 case the patient was eventually judged to have needed nephrectomy instead of the sympathectomy originally performed. Despite absence of post-operative improvement of urinary volume in 2 cases, there was an increased urea content. The author does [illegible] may indicate an [illegible] e kidney. In each [illegible] r after operation, [illegible] with evidence of satisfactory secretion from the opposite organ.

[illegible]

up examinations have been made of 98 per cent of the 219 patients who survived the operation; 100 cases were followed up at 5 years after the operation The results showed that at the end of 5 years the blood pressure had been reduced to normal in 8 cases, and reduced significantly, although not to normal, in 13; in 52 cases the blood pressures were not significantly lower than the pre-operative levels; 27 patients had died. Comparison of these results with those observed after 2 years shows that the results of sympathectomy tend to become less favourable as the length of the follow-up period increases. The material and

BLOOD AND BLOOD-FORMING ORGANS: BLOOD EXAMINATION

See also B.S.P., Vol. 2, p. 159, S. Key 60.

The anaemias

[illegible]

erythrocytes of bizarre multipointed forms, when the red cells are subjected to a reduced oxygen environment In about 3 per cent of individuals with the sickle-cell trait, sickle-cell anaemia develops. The disease usually manifests itself in infancy, but it varies in both severit[illegible] bone-[illegible] cells i[illegible] crises [illegible] such [illegible] defor[illegible] finding[illegible] tissue. The spleen, bones and central nervous system are commonly involved, and less commonly the kidney, liver, spleen and intestinal tract. The acute abdominal pain may strongly suggest the possibility of intussusception, intestinal obstruction, acute appendicitis, ureteral colic or perforation of a viscus. The bone and joint pains have been confused with rheumatic fever or osteomyelitis. Certain marked bony changes are sometimes found. [illegible] necessary to open the abdomen as a precaution. In a case of supposed ureteric calculus, a renal infarct was found.

Wilson, H., Patterson, R. H., and Diggs, L. W. (1950). *Ann. Surg.*, 131, 641.

BLOOD PRESSURE: HIGH AND LOW

See also B.S.P., Vol. 2, p. 189, S. Key 61.

High blood pressure

Surgical treatment of hypertension.—In an EDITORIAL (1950) a survey is made of the value and extent of surgical procedures to be undertaken in the treatment of hypertension. Stress is laid on the difficulties of comparing results in a chronic disorder of unknown aetiology, which takes many years to develop and has so many variable manifestations. There is also a comment on the paucity of controlled series of accurate data, essential before the value of surgery as a therapeutic measure can be evaluated. Mention is made of the particular value [illegible] Keith, Wagener and Barker of the Mayo Clinic, who subdivided [illegible] for 5–9 years; the mortality in the [illegible] one is by Peet and Isberg, and the [illegible] respective grades of patients, it is [illegible] benefited [illegible] of the splanchnic be[illegible] eighth thoracic to the fifth [illegible] coronary heart disease exists, removal from the *inferior cervical to the twelfth thoracic* [illegible] tachycardia exists, removal from the [illegible] the splanchnic nerves, seems to be [illegible] ed are advised.

[illegible] —*For the surgical treatment of hyper*te[illegible] teral adrenalectomy in preference to sym[illegible] nd characteristic symptoms justify the procedure, careful choice of a patient should be based on a normal *fundus* and absence of

be taken for confirmation of diagnosis. Deep x-ray therapy should be reserved for resistant cases.

non-haemato-
tectomy and in
s being elderly
well have been

Fischer, F. (1949). *Nord. Med*, 41, 61.
Lavalle, L L., and Hamm, F C (1949). *J. Urol.*, 61, 83.

BONES—NEW GROWTHS

See also B S.P., Vol. 2, p. 298, S. Key 69.

Benign tumours

phosphorus were made, but all were normal.

Malignant tumours

methods in the present study are most nearly comparable with those obtained by Palmer in 1947. Blood-pressure measurements were taken under routine conditions; later the standard posture and the cold blood-pressure test were used, and subsequent readings were made at hourly intervals throughout the day of the follow-up examination. The authors emphasize the need for improved selection of cases and for the development of more effective techniques.

DeCourcy, J. L. (1950). *J. int. Coll. Surg.*, 13, 619

[illegible]

BONE GRAFTING

See also B.S.P., Vol. 2, p. 225, S. Key 65.

Sources of graft

Use of homogeneous bone grafts.—Weaver (1949) describes his experiences in the use of [illegible]

[illegible] of young adults accidentally killed. The bone was denuded of soft tissue, leaving the [illegible] massive grafts. In the first year of the [illegible] 40° C. Later it was placed in sealed [illegible] 25° C. No preservative chemicals or antibiotics were employed. On being required, the bone was placed in sterile warm saline solution. The shortest storage period was 3 days, the longest 308, and both grafts succeeded. In the series of grafts it was found that the cadaver bone was the most effective, in spite of the fact that the incidence of infection was twice that of patient bone. From this series the author concludes that the method has limitations and dangers, and feels that the results obtained [illegible] supply [illegible] danger [illegible] where [illegible] graft. So far no attempt has been made to sterilize the graft material, but such procedure is being tried. Owing to the ease of supply the author now uses iliac bone from fresh cadavers exclusively.

Weaver, J. B. (1949). *J Bone Jt Surg.*, 31A, 778.

BONES—ACUTE AND CHRONIC INFECTIONS

See also B.S.P., Vol. 2, p. 241, S. Key 66.

Osteitis pubis

[illegible] diagnosis and treatment [illegible] incidence appears to [illegible] weeks, but cannot be [illegible] ndition is trophic. In [illegible] symphysis, rami and [illegible] which soon becomes [illegible]

a rapid response to high dosage of vitamin B alone. It is concluded that treatment should consist of daily intravenous or intramuscular Solu-B, oral administration of high potency B complex, and daily short-wave diathermy to the affected parts. Weekly skiagrams should

area of pachymeningitis is best avoided for fear of the introduction of sepsis. The cavity of a brain abscess is usually entered before identification has been made, and its purulent contents may defy aspiration by needle or trocar. After the cavity has been laid open, the contents are evacuated by suction Iodoform ribbon-gauze is introduced for drainage purposes between the blades of a Killian nasal speculum, and is changed at intervals of from 5 to 14 days. Leptomeningitis may render the diagnosis of brain abscess obscure; in such circumstances, resort to ventricular estimation or ventriculography may be of valuable assistance.

Harpman, J. A. (1950). *J. Laryng*, 64, 319.
Pennybacker, J. (1950) *Ann. R. Coll Surg. Engl.*, 7, 105.

BRAIN—INJURIES AND COMPLICATIONS

See also B.S.P., Vol. 2, p. 349, S. Key 74.

Late complications of brain injury

[illegible]

subdural haematoma in early infancy or adult life The author's cases are collected into [illegible]

cases straight x-ray films can also show pathognomonic changes The author's cases ranged in age between 12 months and 20 years, and all but 1 case were males. Fracture of the skull was associated in only 1 case. In group 1 cases a ventriculogram shows typical deformity, but the haematoma is often encountered when the burr-hole is made for ventriculography; angiography alone would firmly establish the diagnosis prior to operation. In group 2 cases the important radiographic features are as follows. (1) Forward bulging of the middle fossa, which is formed by the greater wing of the sphenoid bone This sign is best [illegible] noid [illegible] right [illegible] nths [illegible] The [illegible] most [illegible]

signs were pathognomonic in 12 out of 15 cases If these are recognized, a small burr-hole over the squamous temporal bone will drain and effect a cure, saving the patient from a ventriculography and possibly a bone-flap Nevertheless two academic problems remain: (1) Why does the middle-fossa floor bulge more than the convexity where the haematomas form classically? (2) Why does such a distortion of the sphenoid occur only in this condition?

Blunt head injury

Pathology.—SIMPSON (1949) examines the pathology of blunt head injury. The skull is [illegible]

148 grammes of urethane. The most interesting point was that hyperglobulinaemia never occurred; the values were, in fact, low, with normal albumin and slightly lowered total proteins. Howe's method for salting-out was utilized. There was no proteinuria and no Bence-Jones protein, no sign of kidney damage or failure and no evidence of amyloid could be found. The author considers, therefore, that this case refutes Bing's theory that the plasma cells are the place of origin for the globulins—certainly there is no quantitative relationship between them. It also refutes the theory of Lichtenstein and Jaffé, that only smaller-type myeloma cells are associated with normal serum proteins. The case also contradicts Waldenström's view that increased formation of globulin is the primary process, with plasma cells secondary to store the globulins, showing an analogy with lipoidosis. Treatment of the condition remains symptomatic. X-ray therapy, although on an incorrect diagnosis, helped at first. The author could not obtain Stilbamidine (diamidine) and therefore tried urethane. [illegible] drug had an [illegible] he myeloma [illegible] treatment. [illegible] The nausea [illegible]

Aas, K. (1949). *Acta. med. scand.*, 135, 426.
Coley, B. L., and Lenson, N. (1949). *Amer. J. Surg.*, 77, 3.

BRAIN—ABSCESS

See also B.S.P., Vol. 2, p. 323, S. Key 71.

Diagnosis and treatment

[illegible] prefer- [illegible] a crisis. Exploratory burr-holes may have to be employed. As regards treatment, [illegible]acker is convinced that to incise and drain these abscesses is wrong. Only 1 patient treated thus, [illegible] 1938, recovered out of 17 cases. Difficulties occur because such abscesses may be [illegible] which causes trouble later. [illegible] that it can be eventually [illegible] weeks while a capsule forms, [illegible] and replaced with penicillin [illegible] procedure is repeated when [illegible] a temporary decompression may be required.

[illegible] on the lessons [illegible] is enhanced by [illegible] sed by awaiting [illegible] penicillin and [illegible] is continued [illegible]

[illegible] ectomy, for its [illegible] panic attic and [illegible] ce of intradural [illegible] bscesses may be [illegible] on of cerebellar [illegible] but there is less [illegible] tuation than in [illegible] ould be sought [illegible] ion through an

the medial inferior quadrant to the lateral ventricle, and this is done under direct vision with a lighted brain retractor. The leucotomy is completed by means of a blunt speculum; a curved instrument, such as a small-calibre suction tip, must be used in the lateral upper quadrant. Injury to the larger arterial branches must be carefully avoided, to prevent

the nucleoproteins of proliferating-cell nuclei might be high, in addition to a concentration in the intracellular inorganic constituents. Experience confirmed this. The extensive use of the substance therapeutically in leukaemias removed any fear of toxicity. A half-life of 14·3 days is convenient for obtaining and storing the drug, without exposing the patient unduly to ionizing radiation. In addition, since its emission consists of pure negative *beta* radiation with a maximal energy of 1 69 Mev., this soft radiation is effectively absorbed

surface. The 4 failures include 2 cases in which necropsy revealed that the counter was never introduced sufficiently close to the tumour; there was 1 case in which, because diffuse gliomatosis was present, no normal area was available for control. In the fourth case the patient has since recovered, so that it seems possible that no tumour was ever present

Poppen, J L. (1948) *J. Neurosurg.*, 5–6, 514.
Selverstone, B., Sweet, W. H., and Robinson, C. V. (1949). *Ann. Surg* , 130, 643.
Tibbetts, R W. (1949). *Brit. med. J.*, 2, 1452.

BREAST—CARCINOMA OF

See also B.S.P., Vol. 2, p. 456, S Key 77.

Pathology

Investigation of internal mammary lymph chain in carcinoma of breast.—It is pointed out by HANDLEY and THACKRAY (1949) that the so-called Stage I cases of carcinoma of the breast show a mortality from recurrence of about 25 per cent within 5 years of radical mastectomy, and that hitherto the only lymphatic exit for carcinoma cells from their place of origin to be adequately studied has been the axillary lymphatic pathway The authors have investigated the internal mammary lymph chain in 50 cases of carcinoma of the breast. The anterior mediastinum was explored through the second or third intercostal space. Specimens removed for investigation always included material from the primary growth

3 cases in which this was done as a preliminary study, exploration showed such a heavy invasion of the space that surgical intervention was abandoned in favour of radiotherapy.

must be sufficiently rapid. The results of head injury are functional and structural. Concussion is an immediate interference with function and the lesions are of no sign...
The natural response to any injury to living
oedema and, if blood vessels are injured, hae
of a torn middle meningeal artery or sinus.
point is the lucid interval after the injury when a further incident may occur before the terminal unconsciousness. Recurrent bleeding may follow a subdural haemorrhage with

... type of parkinsonism.

Bull, J. W. D. (1949) *Brit. J. Radiol.*, 22, 68.
Simpson, K. (1949). *Ann. R. Coll. Surg. Engl.*, 4, 4.

BRAIN—TUMOURS AND TECHNIQUE

See also B S.P., Vol. 2, p. 420, S. Key 76.

Treatment

Prefrontal leucotomy in a case of hypertension —A case in which prefrontal leucotomy was performed on a hypertensive patient is reported by TIBBETTS (1949). A housewife, aged 54

and gain in weight were noted after 2 months. The next 6 weeks were spent in a rehabilitation centre, where improvement continued, especially from the occupational standpoint. An epileptiform attack occurred, and treatment with phenobarbitone was instituted. Examinations have been made about every 2 months, the last being 16 months after the operation. The most striking changes have been noted in the blood pressure, which has remained

ship between the mental tension and the raised blood pressure.

A technique of prefrontal lobotomy.—POPPEN (1948) describes a technique for prefrontal ... 1 per cent. The ... white tissue is ... -ior half of the scalp is shaved and prepared under light thiopentone anaesthesia. With the patient in a semi-Fowler position, the incision region is infiltrated with 1 per cent procaine Anatomical landmarks such as the pupils and the coronal suture are used instead of skull measurements. Two parallel incisions 4 centimetres in length in a sagittal plane are made, in line with each

frontal lobe, arterioles emerging from the anterior horn and fanning out into the contiguous white tissue forming a valuable guide. Care must be taken to divide all the white tissue on

the medial inferior quadrant to the lateral ventricle, and this is done under direct vision with a lighted brain retractor. The leucotomy is completed by means of a blunt speculum; a curved instrument, such as a small-calibre suction tip, must be used in the lateral upper quadrant. Injury to the larger arterial branches must be carefully avoided, to prevent

operation, after all other standard methods of tumour localization had been completed. Radioactive phosphorus was studied because it has been demonstrated that its turnover in normal brain tissue is low, and because it was considered probable that its concentration in the nucleoproteins of proliferating-cell nuclei might be high, in addition to a concentration in the intracellular inorganic constituents. Experience confirmed this. The extensive use of the substance therapeutically in leukaemias removed any fear of toxicity. A half-life of

xposing the patient
pure negative *beta*
effectively absorbed

surface. The 4 failures include 2 cases in which necropsy revealed that the counter was never introduced sufficiently close to the tumour; there was 1 case in which, because diffuse gliomatosis was present, no normal area was available for control In the fourth case the patient has since recovered, so that it seems possible that no tumour was ever present.

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3 cases
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Exami
16 case
the deposits were in lymphatic glandular tissue, in 2 cases in the connective tissues adjoining the internal mammary artery, and in 1 case within the lumen of a mediastinal venule; in 15 instances the axilla alone was invaded; 16 cases showed no glandular deposit anywhere. An analysis of the results shows that the internal mammary chain is involved either at the

same time as, or before, axillary invasion when the primary growth is in the ...
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an uneventful recovery.

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... es a case
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examination then showed a stony hard nodule, 9 millimetres in diameter, at the lower border

...

irradiation was given, and 8 months later the patient had gained her pre-operative weight. The author comments that it would be difficult to understand how metastasis to an axillary lymphatic gland could occur from a primary tumour situated elsewhere than in the regions drained by the afferent lymph channels. Yet he knows that it has occurred, and Jackson, in a personal communication, has described such a case in which the primary tumour was in the liver. Cogswell agrees with Jackson, however, that any woman, in whom biopsy of a lymph-node shows a carcinomatous deposit, should be advised to undergo a radical mastectomy, if no other primary site can be determined.

Treatment

Temporary relief by testosterone in female patients.—Temporary relief of symptoms in mammary cancer, obtained from the administration of testosterone, is described with the

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... better to androgen treatment than do
... lytic areas has been noted. The
... mencement of treatment, a high
... doses are essential and, once
palliation is achieved, a maintenance dose, sufficient to ensure a negative vaginal oestrogen effect, should be decided on, the development of secondary masculine characteristics and increased libido being disregarded.

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ministered, for fear of damage to surrounding tissues. Regarding pre-operative ...

Adair tried this for 5
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experiment he turnec
involvement used onl;
it up with irradiation
5 years Haddow anc
oestrogens, diethylstilboestrol and triphenylchlorethylene, on various neoplastic diseases. The first suggestion of using testosterone in breast cancer was made by Loeser in 1939. A "hormone team" was organized at the author's hospital to investigate the use of these substances in advanced human mammary cancer. So far results have not been very con-

effect a cure. One fact is stated to be certain—androgen and oestrogen therapy should be used only when surgical measures and x-ray irradiation have failed.

Tumours of the male breast

Incidence, diagnosis and treatment—Payson and Rosh (1949) review the incidence, diagnosis and treatment of tumours in the male breast.

symptoms before examination tended to be longer than in women, the average period being 3 14 years. Involvement of the axillary glands and pectoral fascia and distant metastases were found in a large proportion

The prognosis in male mammary cancer is poor, only an 18·8 per cent 5-year cure-rate being obtained.

Adair, F. E. (1949)

BRONCHIECTASIS

See also B.S.P., Vol. 2, p. 501, S. Key 81.

Complications

Sloughs of tracheal mucosa associated with bronchiectasis.—TURNER (1949) records 3 cases

aged 27 years, essentially similar symptoms developed after pneumonectomy for bronchiectasis. The slough in this case was adherent, and for its complete removal bronchoscopy had to be performed on 2 occasions, 3 and 7 days after operation. On the second occasion a roughened area of mucosa was seen on the whole circumference of the trachea. In both these cases, No. 9 "Protex"

each one Inflation was by I

sterilization. It was consid

cuffs. In Case 3, a boy aged 11 years who had undergone lobectomy for bronchiectasis, progress was complicated by the uncooperative attitude of the patient, who had to be urged to

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head had been turned had forced

rynx, and possibly also the upper

mall to allow expulsion of such a slough, and the condition is aggravated by the anoxia and consequent congestion.

Turner, F. L. (1949) *Lancet*, 2, 237.

CAESAREAN SECTION

See also B.S.P., Vol. 3, p. 1, S. Key 84.

Indications

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Dannenberg, M., Beilly, J. S., Rodney, M. B., and Storch,
Roentgenol., 64, 53.

CHORDOMA

See also B.S.P., Vol. 3, p 51, S. Key 91.

Distribution

Sacro-coccygeal chordoma and chordoma in other areas.—HALPER (1949) reports on a case of sacro-coccygeal chordoma, reviewing the literature and enumerating the radiological

signs. Chordomas occur in the sacro-coccygeal and spheno-occipital regions; rarely they are found in the jaws and vertebrae. About 70 per cent occur in males. The average age of onset is 40–50 years, but no age-group is exempt. Whether benign or malignant, the tumours remain encapsulated Local recurrence after removal is common. Malignant metastases are commonest from chordomas in the sacro-coccygeal area and occur late. Symptoms are due to pressure and erosion, and therefore are not characteristic. Pain is common and a history of trauma frequent. Sacro-coccygeal chordomas are often palpable, and vertebral types sometimes produce soft-tissue swelling Radiologically, sacro-coccygeal cases are typical. Expansion, rarefaction, trabeculation and calcification occur typically in the lower sacrum. Expansion occurs in all diameters, with or without preservation of bone outline. Rarefaction occurs in loculated areas or in large areas of bone destruction. Trabeculation results from undestroyed bone, and may extend into the soft-tissue mass Irregular calcification of low radio-opacity is the result of new-bone formation or calcification in necrotic areas. Cranial chordomas are seldom diagnosed, because typical honeycombing is rare and the calcification frequently seen is misinterpreted as a craniopharyngioma In vertebral cases x-ray findings are unhelpful Myelograms are valueless.

Halper, H (1949) *Brit J Radiol*, 22, 88

COAGULANTS AND ANTICOAGULANTS

See also B S.P., Vol 3, p 76, S Key 95.

Coagulants

Human fibrin foam and thrombin solution—STATE (1949) describes the use of human fibrin foam and thrombin solution as haemostatic agents in general surgery for the control of oozing from capillaries and small vessels This technique avoids the disadvantages inherent in the older practice of packing with gauze Fibrin foam is prepared from the

moisture has been removed. In an emergency a supply can be prepared in 1 minute. The

oozing which occurs in such situations as the depths of a

completely absorbed The tissue reaction is limited to the presence of a few polymorphonuclear leucocytes. The authors used Oxycel as a haemostat
and chronic anal fissur
in most of the operative
bleeding arteries and

Ault, W A , and Madigan, E. P. (1949). *Amer J. Surg*, 77, 352.
State, D. (1949) *Arch. Surg., Chicago*, 58, 284.

COLITIS

See also B.S.P., Vol. 3, p. 88, S. Key 97.

Operative treatment

Ileostomy in ulcerative colitis.—Ileostomy in the treatment of ulcerative colitis is discussed by HARDY, BROOKE and HAWKINS (1949). Ileostomy provides the only means of putting the

[illegible]

balance tests are used to ascertain ileo-jejunal function. The dietary salt is increased by

[illegible]

used invariably, Cattell's own technique being followed with certain modifications Anaes-

[illegible]

the peritoneal cavity is opened, and this addition to the operation has not

[illegible]

added. The foods which

on, and their suitability

must be learned by experience Ileostomy has been performed 21 times with 6 deaths; 2 patients died shortly after being operated on as a measure of last resort. Of 3 deaths from

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occurred in 2 cases of "loop" ileostomy,

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face, drying and later charring the

the electrode to the tissues, finally

al fulguration may be needed in the

case of large lesions. The proctoscope used must be equipped with means for removal from the bowel during fulguration of smoke and gas, and also of faeces and fluid. General *anaesthesia should never* be employed. Caudo-sacral anaesthesia may be used in cases of anal or perianal involvement, or when adequate exposure cannot be obtained, *but usually*,

anaesthesia is neither necessary nor desirable. Care must be taken in fulguration to avoid too much destruction of the bowel wall. Sessile lesions up to 6–8 millimetres in diameter may be fulgurated, even in the mobile portion of the colon Fulguration is best applied to

series they occurred only in cases of massive lesions in the rectum, requiring extensive

associated with diffuse hyperplasia of the mucous membrane

Buie, L A , Smith, N D , Jackman, R. J., and Hill, J R (1949) *J. Amer med. Ass.*, 139, 702
Hardy, T L , Brooke, B N , and Hawkins, C. F (1949) *Lancet*, 2, 5.

DEFORMITIES

See also B S P , Vol 3, p. 180, S Key 106

Arthrogryposis

Aetiology and treatment—STEINDLER (1949) discusses arthrogryposis in general terms, having had experience of 60 cases After a review of the scanty literature he defines the condition as a deformity produced essentially by distortion of a number of joints These contractures are associated with a primary muscle degeneration resembling the myodystrophies of later years with no bone aplasia. But a secondary joint capsule contracture is

Steindler recognizes two main types, according to whether the limbs are contracted in flexion or extension, and these he subdivides according to the limbs affected Mixed contractures, some in flexion and others in extension, can occur. In treatment conservative

better the younger the

ective manipulations

very obstinate, as is

the degree of muscle

degeneration, but only a few cases show no benefit from treatment Development of the muscular apparatus, however, must form the main after-treatment. Resistant cases can be helped by judicious surgery. Plastic capsulotomies, osteotomies and resections of joints may be considered Sometimes nerves and vessels form the major obstruction to restoration of joint position, and it is here that osteotomies in the neighbourhood may give a pseudo-correction There is, however, a tendency for recurrences of the deformity after operation, and protective braces may have to be worn for a considerable time Most lower limb cases, however, finally become ambulatory without appliances and a satisfactory use is eventually made of affected upper extremities.

Pectus excavatum

Operative treatment—RAVITCH (1949) describes in detail the operation he performs for pectus excavatum, describing 8 cases There was one death from empyema in a child of nearly four years who also had a right lower lobe bronchiectasis The deformity involves a sharp posterior curve of the body of the sternum, deepest inferiorly The lower costal cartilages bend inward to form a depression. It is present at birth and usually is progressive, and since the mechanism of its production is uncertain it is impossible to tell in which children progression of the deformity will occur. Secondary changes involve a flat, thin chest with a

can be divided, after which the sternum can be slightly elevated, even without division of the costal cartilages. Operative correction should be undertaken, for cosmetic reasons, to prevent or improve secondary deformities and to limit arrhythmias or increase exercise tolerance. The younger the patient at the time of operation the greater the chances of

are exposed for the full extent of their deformity. The two lowermost cartilages are then removed with no attempt to preserve perichondrium in infants or children One can then expose and divide with scissors the xiphisternal joint. The substernal ligament is then divided and the xiphisternum pulls well away. Retaining attachments of rectus muscles are divided and a finger is introduced into the mediastinum and the sternum freed of diaphragmatic attachments to the manubrium. The full length of all remaining deformed costal cartilages are now removed on both sides The number varies with the severity of the

position reinforced by interrupted 00 silk sutures through the periosteum The pectoral muscles are resutured in position, but no attempt is made to suture the costal cartilage ends to the sternum and external traction by wire was abandoned after a fatal pyogenic infection The paper concludes with details of the 8 cases with case photographs.

Ravitch, M. M (1949). *Ann. Surg*, 28, 429.
Steindler, A. (1949) *J. int. Coll Surg.*, **119**, 21.

DIABETES MELLITUS IN RELATION TO SURGERY

See also B S.P., Vol. 3, p. 250, S Key 108.

Pregnancy in diabetic patients

Foetal mortality.—Wynne-Jones (1949) records 20 cases of pregnancy in diabetic mothers, ... series showed a corrected foetal-mortality rate ... of 19 5 per cent. One mother, who had had ... hospital in pre-coma The causes of ... 1) Frequency of abortion, attributed t ... or (*b*) diabetic imbalance, with adve ... mature labour (3) Foetal death *in utero*, particularly from ketosis in the last month of pregnancy. (4) Hydramnios, due (*a*) to the high glucose content of the liquor amnii, making it hypertonic, (*b*) to foetal diuresis, or (*c*) to toxaemia. (5) Increased weight of the baby, partly of endocrine origin (6) *Congenital abnormalities, of unknown origin*. (7) Ketosis, resulting from (*a*) reduced power of the blood to combine carbon dioxide, (*b*) increased basal metabolic rate, (*c*) loss of maternal carbohydrate to the foetus, and (*d*) increase of blood fats (8) Neonatal hypoglycaemia: in 1 case in the series a severe cyanotic attack was relieved dramatically by the administration of glucose. (9) Maternal toxaemia: 1 patient in the series ... at the twenty-fourth week, and surgical induction resulted in the

with a constant watch for "silent" ketosis and prompt admission to ... doubtful diabetic stability; (2) co-operation between physician and obstetrician; (3) routine induction of labour at about the thirty-sixth week; (4) careful nursing of the babies, who should always be regarded as premature. Soluble insulin should be used, and no insulin should be given to the mother within 3 hours of delivery

Treatment of diabetes

... in the treat- ... far as ... it as ... eadths ... he ... of

20 degrees. At a depth of 4–5 centimetres the operator will strike the transverse process of the vertebra. The needle is next made to pass above or below the bone and is then advanced another 3 centimetres When the needle strikes the body of the vertebra, it is pushed a further centimetre, to lie tangentially on the antero-lateral surface of the vertebral body. Throughout the injection 1 per cent Percaine is used to obtain anaesthesia When the needle is in position, and if aspiration yields neither blood nor cerebrospinal fluid, 10 millilitres of the anaesthetic are injected Proof that the splanchnic nerve has been anaesthetized is given by a pleasant sensation of warmth progressing down the patient's lower limb From 1 to 2 millilitres of 95 per cent alcohol are then injected. Rabboni has had no complication following injection, but he mentions the possibility that the needle might enter a spinal [illegible]

but the results were only temporary, lasting for a period varying from 3 to 12 months A repeat injection produced a further decrease in glycaemia He intends to publish long-term results, indicating whether the curative effect will ever be permanent. In his experience, diabetes is usually associated with arterial hypertension, and this treatment, when it relieves the one condition, will favourably affect the other. If it fails, neither the glycaemia nor the blood pressure will be reduced

Rabboni, F. (1950). *J. int. Coll. Surg.*, **13**, 312
Wynne-Jones, E (1949) *S. Afr. med J*, **23**, 654.

DIVERTICULA OF THE ALIMENTARY TRACT

See also B S P., Vol 3, p. 256, S Key 109.

Diverticula of the duodenum

Diverticula of third part—The literature pertaining to the extremely rare condition of diverticulum of the third part of the duodenum is reviewed by SPANN, SINGMASTER and ENGEL (1949), in an article which directs attention especially to surgical approach and technique in this condition They consider that the main problem in the excision of diverticula of this portion of the duodenum is one of adequate exposure. On the basis of their experience with the case which is described in some detail in the article, the authors re-emphasize the following points in procedure (1) The surgical approach is through the duodenum, care being taken to avoid the middle colic artery. (2) In order adequately to demonstrate the diverticulum, which is usually on the postero-superior surface of the [illegible]

amputated at its neck In the case described, convalescence was interrupted on the twelfth post-operative day by a sudden rise of temperature and by epigastric pain, nausea and vomiting Further operation next day showed the presence of a periduodenal abscess, which was drained through the gastrocolic omentum. In view of this experience, the authors are in favour of inserting a rubber-tube drain into the site of operation through the gastro-

[illegible]

[illegible] and [illegible] 4 per cent of external faecal fistulae A study has been made of 46 cases of [illegible]

[illegible] could not be identified, the excised segment of bowel was all that was available for study. The length of colon excised averaged 14 centimetres. The involved segment was usually

thickened and rigid and contained multiple diverticula. Abscess formation, granulation,

muscle

noted.

cases in

but recurred when the fistula closed spontaneously. Constipation was a frequent feature. There was no instance of diarrhoea. Every fistula occurred after some form of surgical

observed for about 12 months. A temporary transverse colostomy should usually be performed 6 months *prior to resection.*

Diverticula of the caecum

(*a*) *by migration of a purse-string suture, or* (*b*) *by rupture of an abscess of the appendiceal* stump; (3) constipation or increased intra-abdominal pressure; (5) inherent weakness of the bowel wall, due to age, obesity or other factors; (6) traction on the mesentery or omentum; (7) trauma secondary to a previous operation; (8) retention in residual form

Pre-operative diagnoses have usually

but have included degenerated

rator hernia and benign caecal

ulcer

may

ole resection of the

ich more common

colon. Sequelae of

abscess formation,

essitate colectomy

chemotherapy, as

ne procedure.

Henry, F. C. (1949) *Ann. Surg.*, 129, 109.
Mayfield, L. H., and Waugh, J M. (1949). *Ann Surg.*, 129, 198.
Spann, R. G., Singmaster, L., and Engel, G. C. (1949). *Amer. J. Surg.*, 77, 392.

EAR—AVIATION, SURGICAL ASPECTS OF

See also B.S.P., Vol. 3, p. 282, S Key 111.

Blast perforations of the ear-drum

Aetiology and treatment.—The methods of modern warfare have greatly increased the incidence of blast perforation of the ear drum. RICE (1949) reports a series of 87 such cases seen within 72 hours *of injury in none of which was there evidence of thermal or* chemical damage or of contamination with foreign substances. The causative factor in each case was thus an uncomplicated severe compression wave. Assessment of injury was made on the size of the perforation and the extent of ecchymosis present, the cases *being divided into*

rolling back of the edges of the tear and not by loss of substance of the drum Such cases

ration

Rice, A. H (1949) *Arch. Otolaryng., Chicago,* 49, 316.

EAR—EXTERNAL EAR

See also B S P , Vol 3, p 286, S. Key 112

Foreign bodies in the meatus

Delayed onset of symptoms due to foreign bodies.—WARREN and BIVINS (1949) report

the facial palsy was unchanged. The second patient attended with a painful swelling in the left mastoid region of one week's duration Two years previously a large abscess had developed in the left post-auricular region and ruptured into the external auditory canal, but the

Warren, W. C., Jun , and Bivins, T. E. (1949) *Arch. Otolaryng , Chicago,* 49, 196.

EAR—MALDEVELOPMENTS OF

See also B S P , Vol. 3, p 303, S Key 115.

Abnormality in size of the auricle

Deformities encountered in a microtic ear.—As a result of their separate development, the

down to the head, *the ear in* which *only* a normal concha and lobule are present, to the congenitally absent auricle with either an atresic or completely absent external meatus. Facial asymmetry or maldevelopment of the ramus of the jaw may accompany this last type of deformity, in which *failure of branchial* development is more widespread. Providing the drum can be seen, hearing [illegible] impaired it is usually due [illegible] operation is sought merely [illegible] Holmes advises that nothing should be attempted *in the case of a girl* who can hide her deformity under her hair. Even the best [illegible]

[illegible] st type of case, even in the presence of [illegible] canals, cochlea and ossicles, operative [illegible]

Holmes, E. M (1949). *Arch. Otolaryng., Chicago*, 49, 243.

EAR—OTOSCLEROSIS

See also B S P., Vol 3, p 337, S Key 121.

Operative technique

Haemostasis during fenestration operations.—Hall and Millar (1950) present a routine for the maintenance of haemostasis during the fenestration operation without the need for local anaesthesia with its attendant disadvantages. Their operation time has been reduced to about 2 hours. Ischaemia is obtained by the planned production of hypotension, using spinal anaesthesia without sacrificing the safety factor. Omnopon, $\frac{1}{4}$ grain, and hyoscine, [illegible]

[illegible] quantity depending on the build of the patient and the pre-operative blood pressure. Barbotage is used to obtain a high level of anaesthesia, and the table is tilted slightly head down to maintain cerebral circulation. Any straining or coughing is prevented by fractional doses of thiopentone as required. Graphical recordings of blood pressure, pulse and respiration rate are kept and the paper gives illustrative charts. The blood pressure remains down for [illegible] a cause for alarm.

Results of surgical treatment

Fenestration operations.—The results of the first 100 fenestration operations for otosclerosis, performed at the Utrecht University Clinic, are reported on by Jongkees (1949), with reference to the state of the patients 1 year after the intervention. Fenestration was carried out by the endaural route and nearly always under general anaesthesia, the fenestra being fashioned by a diamond burr, as described by Passe. Subsequently, 71 patients were satisfied with the result. Their hearing was checked by audiograms, which, in spite of their [illegible]

whole, the greatest gain in all groups was found at 2,000 and the least at 8,000 high-frequency Moreover, in the patient with poor bone conduction, the average gain was greater, although the practical results were not good.

Hall, I S, and Millar, A. McC (1950). *J. Laryng*, 64, 233.
Jongkees, L. B W. (1949) *Ned. Tijdschr Geneesk.*, 93, 3547

ENDOSCOPY—BRONCHOSCOPY

See also B S P, Vol 3, p 392, S Key 131.

lung were the main findings. At bronchoscopy half a peanut was removed from the trachea. This had caused a partial obstruction, insufficient to produce radiological evidence of atelectasis or emphysema The second and third cases were of children with cough and fever attributed to pneumonia Chest skiagrams in Case 2 showed emphysema of the right lung, which increased with inspiration, thus suggesting bronchial obstruction At broncho-

of the inhalation of a foreign body

Leary, W V. (1950) *Proc. Mayo Clin.*, 25, 353.

EYE—CONGENITAL ABNORMALITIES: HEREDITY IN RELATION TO EYE DISEASE

See also B S P, Vol 3, p 453, S. Key 139.

Contact lens

Ar
of
ser
op
pairs of contact lenses had been prescribed. The majority of the physicians stated that their

replies Analysis of the results of *questionnaires* to patients revealed that in a group of 66 "cosmetic" cases, the patients had used contact lenses for an average of 1·6 years and were able to wear the lenses without

is to tolerate the lenses, but in most cases of either type the
The main problem appears to be blurred
is attributed largely to the pressure on
oedema of the conjunctiva and interferen
The fluid appears to be a minor factor.

Abraham, S. V., and Shanedling, P. D. (1950). *Amer. J. Ophthal*, 53, 933.

FACIAL PALSY

See also B.S.P., Vol 4, p 1, S. Key 147.

Indications and technique

Traumatic palsy: indications and technique for surgical treatment—SCHJELDERUP (1949) discusses the
and site of t
cedures into
disfigurement
hypoglossal

cavity. Length of nerve may be obtained either by re-routing the nerve or by inserting a graft from the lateral cutaneous nerve of the thigh or from the aural nerve. (2) If the nerve cannot be repaired, correction of the facial deformity must be achieved by plastic surgery. It is important to realize that the "sagging" of the face is due to its lack of suspension from the zygoma and maxilla by the zygomatic and other muscles, and that the sound muscles of the other side tend to pull the face over when they contract. Hence, by surgical methods the

tendon (taken from the palmaris longus muscle) to the angle of the mouth. It is well to be contented with a small amount of movement.

operation. Eight days later the left facial nerve was also decompressed, but no lesion was

undertaken.

Kettel, K. (1949). *Nord Med.*, 41, 347.
Schjelderup, H. (1949). *Nord. Med.*, 41, 343.

FACIO-MAXILLARY INJURIES

See also B.S.P., Vol. 4, p 15, S. Key 148.

Fractures of the maxillae

Diagnosis and treatment.—Some aspects of fractures of the maxillae are discussed by HALLAM (1950) In the milder types of injury the following signs and symptoms should be sought: (1) anaesthesia of the lip; (2) anaesthesia of the cheek and the side of the nose; (3) submucous haemorrhage on the lingual aspect of the mandible; (4) disturbance of the normal occlusion of the teeth; (5) pain in the condylar region on moving the jaw (also present in bruising on the inter-articular disc); (6) deviation of the chin, on opening the mouth, towards the side of the injured condyle; (7) limitation of mandibular movement; (8) disturbance of the normal continuity of the palpable area; (9) crepitus. Predisposing

measure in severe cases, asphyxia from loss of control of the tongue being almost the only cause of death. Patients should be reassured regarding difficulties with speech and feeding.

bandage should never
sling, which can be m
adhere. Any dislocatec
suture of wounds sho
should be taken as ec
achieved by either intra-oral or extra-oral methods, the latter being used more frequently.

Cleft lip and palate

Dental aspects of treatment of clefts and perforations of the palate.—The dental aspects of the treatment of clefts and perforations of the palate are discussed by LIDDELOW (1950). Successful repair of palatal defects necessitates the co-operation of a team consisting of the surgeon, the dental surgeon and the speech therapist. Clefts of the palate may be classified as: (1) congenital and (2) acquired. (1) The congenital types comprise 3 groups: (*a*) the pre-alveolar, which involve only the tissues in front of the alveolar ridge and are usually referred to as "hare-lip"; (*b*) the post-alveolar, which are clefts of the palate posterior to the

obtained by the surgeon alone. The cleft in these cases may cause teeth to be misplaced, loose on eruption or even suppressed, or may give rise to supernumerary teeth. Early surgical treatment
(2) Acquir
from syph
excision o
protect the wound, assist deglutition and speech, and prevent the patient from becoming

. alternatively a more
lip and osteoplastic

FISTULA IN ANO

See also B.S.P., Vol. 4, p. 102, S. Key 154.

Surgical anatomy of the anal canal

Ischiorectal space.—MORGAN (1949) describes the surgical anatomy of the ischiorecta space The accepted view, that the levatores ani descend like a funnel around the viscera canals, derives from dissection of aged subjects *and does not* accord with the actual finding in operative surgery. In pronograde animals, such as the dog, the slit-like pelvic outlet

which is intimately attached to the remaining portion of the levator)

lower compartment—the perianal space—rarely penetrates upwards through the perianal fascia into the ischiorectal space proper In an acute ischiorectal abscess the whole space may be involved, but the pattern of a chronic fistula is determined by the anatomical

40 of the author's cases of high-level fistulae He recommends the first incision for ano-

Morgan, C. N. (1949). *Proc R. Soc. Med.*, 42, 189.

FOOT—SURGERY OF

See also B.S.P., Vol. 4, p 132, S. Key 156.

Morton's metatarsalgia

Clinical features and treatment of Morton's metatarsalgia.—Morton's metatarsalgia is

becomes sharp and lancinating as the patient walks, sometimes forcing her to stop and manipulate the foot The pain may radiate to the outer three toes or to the calf of the leg There is frequently tenderness to pressure, applied posterior to the third and fourth metatarsal heads. The pain was originally believed to be due to neuralgia, produced by pressure on the digital branches of the external plantar nerve, which in certain circumstances—for

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)e
desired.

Metatarsus

sometimes bring
turn their toes in
s varus, which is

(4) Pure congenital metatarsus varus without deformity of the posterior part of the foot. In the first group the operative treatment is aimed at moving the block constituted by the scaphoid, cuboid, cuneiform and metatarsal bone outwards, by suitable operations on the ... In the second group operation is unnecessary, a
llus outwards
vards. In the
operate upon

is also suitable in cases of the fourth group.

Cassart, P. (1949). *Scalpel, Brux*, 102, 67.
Moore, E L., and Meredith, E. W (1949). *Amer. J. Surg*, 77, 399.

FRACTURES, DISLOCATIONS, FRACTURE-DISLOCATIONS AND ALLIED INJURIES

See also B S P, Vol 4, p 165, S. Key 158.

Humerus

Transplant of the musculospiral nerve in the open reduction of fractures.—A technique for transplant of the musculospiral nerve in open reduction of fractures of the mid-shaft of the humerus is described by SCHNITKER (1949). A straight incision is made along the lateral aspect of the arm, posterior to the usual one that separates the brachialis fibres, and the fascia of the lateral intermuscular septum is divided from bone distally to the origin of the brachioradialis muscle The brachialis muscle is retracted anteriorly and the lateral head of

centimetres, the superficial cutaneous branch also can be dissected free to the brachio-axillary angle, or it can be sacrificed with minimal sensory impairment The brachialis is

and the healing of the fracture

Radius and ulna

Aspiration of elbow joint following fractures of the radial head.—QUIGLEY (1949) calls attention to the usefulness of aspiration of the elbow joint in the treatment of undisplaced fractures of the radial head and also in clarifying the indications for arthrotomy in fractures with moderate displacement. Fractures of the radial head fall into three groups: those in

elapsed after the injury lest the haemarthrosis recur. With the forearm pronated to minimize the risk of injury to the deep branch of the radial nerve and after infiltration with procaine, a 16-gauge needle is introduced into the joint through the centre of the triangle formed by the head of the rad[illegible] and the lateral epicondyle of the humerus. The persistence afte[illegible] passive rotation is an indicati[illegible] aspiration in the treatment of [illegible] a table.

Intramedullary pins in the treatment of forearm fractures.—STUCK and THOMPSON (1949) discuss the treatment of forearm fractures with intramedullary pins. They stress the fact that most forearm fractures can be treated by closed manipulative reduction and some form of traction. The fractures they consider suitable for intramedullary pinning are transverse [illegible] of one bone and [illegible] l and a [illegible] n; it is [illegible] n. For [illegible]

are closed and a plaster cast applied from the fingers to the shoulder with [illegible] 90 degrees to prevent forearm rotation. After 6–8 weeks the cast is removed, the pins withdrawn, and union checked by x-ray. If defective the cast is re-applied for another month. The patient must always exercise his fingers to avoid stiffness. In 19 cases the authors had two failures, one in an epileptic who fell, the other in an early case when the radial pin had not been properly inserted into the lower fragment. This method was widely employed in World War II by German surgeons using Küntschner's pins

Fractures of the carpal bones and dislocations at the wrist

Bone grafting in non-union of fractures of the carpal scaphoid—GOERINGER (1949) reviews the follow-up results of the [illegible] of the carpal scaphoid by bone grafting which was s[illegible] lication for operation was pain. Only [illegible] r the open operation of bone pegging. [illegible] Wrist fusion is indicated for ancient fractures with a degenerative arthritis Excision of the proximal [illegible] and, if necessary, an [illegible] on [illegible] the [illegible] p is [illegible] be [illegible] the [illegible]

not practicable. [illegible] dorsal carpal ligament is incised and the capsule is opened transversely. [illegible] periosteum over the lower end of the radius permits better exposure of the joint and [illegible] a drill hole is made in the two [illegible] aft is driven [illegible] mmobilized

in a plaster which permits free finger movement but movement only in the distal joint of the thumb which is held in moderate extension and slight abduction.

Femur

Treatment of adduction fractures of the neck of the femur.—DE PALMA (1949) describes a new approach in the treatment of adduction fractures of the neck of the femur. He removes a wedge of bone base upwards from the neck to convert an adduction fracture into an abduction fracture. Twenty-two cases are reported between 62 and 83 years of age with a follow-up of 12–20 months. All united by bony union, but there were 2 cases of aseptic [illegible]

[illegible] absorption of the femoral neck is the result of a traumatic hyperaemia, due to this inadequate immobilization. This can follow poor positioning of the fixation pin or bone-absorption around the pin. Operative details include a Smith-Petersen approach with division of tensor fascia femoris transversely 3½ inches below the trochanter. A vertical incision in the capsule exposes the fracture. Remove a wedge of bone base superiorly from the distal fragment of the neck. The width of the base depends on the obliquity of the fracture-line. The more vertical the fracture-line the greater the width of the base. An adequate support must be created for the proximal fragment. When a "beak" of femoral neck projects from the inferior aspect of the proximal fragment, remove it with an osteotome or it will prevent re-position of the proximal fragment in a valgus position. The proximal fragment is then levered into position and locked by internal rotation and abduction of the femoral shaft. Under direct vision introduce a Smith-Petersen nail. The patients sit up next day, are ambulatory on crutches after 10 days and discard their crutches after 5 months.

[illegible]

injured, the haematoma and fracture detritus are kept, important features in regeneration. BOHLER and BOHLER (1949) have treated 700 cases since 1940. They use the method chiefly [illegible]

transverse or oblique in the middle third of the shaft at least 7 centimetres from the tip of the [illegible]

[illegible]

shortened fractured one. This treatment should not be used for infected or draining fractures.

Talus

[illegible]

partial dislocation of the body involving the subtalar joint; in these cases closed reduction

offers the best prognosis. (*d*) Fractures with complete dislocation are very serious. Closed reduction is nearly impossible and early surgery is indicated. Some authors recommend some type of fusion of the ankle joint [illegible]

[illegible] fusion is painless, it would appear the most logical treatment when satisfactory reduction is impossible or asceptic necrosis occurs.

Bohler, L., and Bohler, J. (1949). *J. Bone. Jt Surg.*, 31A, 295.
De Palma, A. F. (1949). *Ann. Surg.*, 129, 323.
Foley, W. J. (1949). *Amer. J. Surg.*, 77, 19.
Goeringer, C. F. (1949) *Arch. Surg. Chicago*, 58, 3
Quigley, T. B. (1949). *New Engl. J. Med.*, 240, 915.
Schnitker, M. T. (1949). *J. Neurosurg.*, 6, 113.
Stuck, W. G., and Thompson, M. S. (1949) *Amer. J. Surg.*, 77, 12.

GALL-BLADDER AND BILE PASSAGES

See also B.S.P., Vol 4, p. 238, S. Key 161.

Diseases of the gall-bladder

[illegible]

The original transverse incision was closed and a fresh paracostal incision exposing the gall-bladder and bile-ducts made. The gall-bladder and common bile-duct were very distended. To facilitate removal, the portion adjacent to the liver was aspirated and thick dark green bile remo[illegible] the whole gall-bladd[illegible] Several small stones [illegible] The gall-bladder was 8 5 centimetres long and 4 centimetres broad. Section revealed two [illegible]

[illegible] his own. Boyden, whose classification of double gall-bladder is generally accepted, found only two cases in 9,221 cadavers He divides the anomaly into two groups: (1) vesica diversa which has a septum dividing the organ into two chambers draining into a common [illegible]

Operative technique

[illegible]

surgery wit[illegible] thoroughly, [illegible] bladder. A [illegible] and duct must be separately ligated and divided. It [illegible] of adhesions, partial cholecystectomy or drainage of [illegible] procedure Familiarity with the various anatomical variations of the region is essential. Immediate anastomosis of the severed duct must be made if the injury is recognized at the time Tubes must not be fitted tightly into the ducts, there must be no tension on the sutures, and these should not be placed in the lumen. [illegible] is a formidable [illegible]

operation in cases of gall-bladder disease. If the ducts are injured at operation, repair must be undertaken as soon as possible.

Gall-bladder paracentesis by a transparieto-hepatic approach.—The encouraging results of liver biopsy have prompted KAPANDJI (1949) to evolve a technique of gall-bladder para-

infiltrative method. The avoidance of exploratory cholecystotomy ensures the absence of a

to the water-tight nature of the puncture.

Kapandji, M. (1949). *Bull. Soc. méd. Hôp. Paris*, 65, 845.
Meyer, J. H., Dowlin, Winifred, and Reinglass, S. S. (1949). *Amer. J. Surg.*, 77, 117.
Thorlakson, P. H. T. (1949). *Canad. med. Ass. J.*, 60, 119.

GASTRO-COLIC FISTULA

See also B.S.P., Vol. 4, p. 272, S. Key 164.

Operative technique

Gastro-jejuno-colic fistula: a report on two cases.—VAUGHN, HOLLISTER and LAGORIO (1949) review the condition of gastro-jejuno-colic fistula and report two cases treated by surgery with a 2½-year and 3-year follow-up. The condition usually follows a gastro-

enumerate the factors precipitating gastro-jejunal ulceration after gastro-intestinal anastomosis thus:

close beneath the anastomosis. Only rarely does the stomach connect directly with the

this to the rapid peristalsis produced by colonic material regurgitated into the upper gastro-intestinal tract. This results in marked weight loss, anaemia and a low serum protein. The weakness and dehydration may become extreme. Eructation of a stercorous smelling gas may occur and faecal material may be vomited. Abdominal pain situated below and to the

employed. The treatment is surgical but careful pre-operative preparation is essential, for the operative mortality is high. Modern operative adjuvants allow a one-stage procedure

but some advocate a two-stage procedure especially in the presence of inflammatory adhesions. Pfeiffer and Kent advise a preliminary

Swinton, and also Marsha

agree that the ideal proced

of gastro-intestinal contin

marginal ulcer. They, however, in their two cases, removed only that portion of stomach adjacent to the fistula and, having excised the fistula, performed an anterior gastro-enterostomy using a portion of the jejunum distal to the previous anastomosis. In one case a portion of colon was resected. In the other the small fistulous opening was invaginated In both cases the involved portion of the efferent loop of jejunum was excised and the loop reconstituted by a lateral anastomosis. They consider that this is an operation of lesser magnitude, requiring shorter time, and therefore likely to have a reduced operative mortality. This was weighed against the risk of a future recurrence of a marginal ulcer. They believe, however, that one patient, because of two previous perforations, is a candidate for future gastro-intestinal ulceration. Should this occur they consider supradiaphragmatic vagotomy the procedure of choice and the patient has already agreed to this should they consider it advisable.

Vaughn, A. M., Hollister, L. C., and Lagorio, F. A , Jun. (1949). *Amer. J. Surg.*, 78, 99.

GLAUCOMA

See also B S.P., Vol. 4, p. 319, S. Key 169.

Pathogenesis

Aqueous veins —Aqueous veins and their significance for the pathogenesis of glaucoma are discussed by ASCHER (1949). The smaller veins are biomicroscopically visible, while

1 centimetre or slightly more; the width ranges from 0 01–0 1 millimetre. The amount of

eyes they become visible after successful surgical intervention The presence of a pressure differential between the two fluids has been demonstrated experimentally; de Vries noted the "blood influx phenomenon" in veins with low speeds of flow and the "aqueous influx

from a reduction in the number of outlets, as might occur after a cataract incision. The

ort histologically

The results of the

ving of the canal

in at least some

Treatment

sclera with galvano-cautery, were restricted by the risk of damage to the ciliary body. The use of diathermy opened a new epoch, and superficial coagulations of the ciliary body were performed, sometimes associated with perforating punctures. The method of Vogt, which has since been used widely, consists of multiple diathermic perforations of the sclera in the ciliary region; a modification with only a few perforating coagulations, without conjunctival dissection, is advocated for buphthalmos Complications, including phthisis bulbi, have led to more harmless methods being suggested Superficial non-perforating diathermy, on the bared sclera or over the conjunctiva, is a less radical method, although the results are less permanent. The present author has treated 21 cases by solid carbon dioxide cauterizations of the conjunctiva; the applications, usually not more than 8 in number and each lasting

ciliary body, include diathermo-coagulation of the long posterior ciliary arteries, or of the anterior ciliary arteries, and electrolytic anodic cyclodialysis As superficial methods are less dangerous and their action sometimes only temporary, they are particularly advisable when a transient lowering of tension is needed, as in the hypertension which follows keratoplasty.

Ascher, K. W. (1949). *Arch. Ophthal*, *Chicago*, 42, 66.
Bietti, G (1950). *J Amer. med. Ass.*, 142, 889.

HAEMATOMA

See also B S P., Vol 4, p. 361, S. Key 175.

Clinical features

Haematoma of the umbilical cord.—A case of haematoma of the umbilical cord is recorded by SCHWARTZ (1949) A multigravida, aged 25 years, was admitted to hospital in active

at its base, was enclosed on the foetal surface between the amnion and chorion. One of the umbilical veins showed, on dissection, a longitudinal opening, 1 centimetre in length, situated 1 centimetre from the foetal surface of the placenta. Histological examination of

within the adventitial wall

Schwartz, J (1949) *N Y St. J. Med.*, 49, 1575.

HEART AND PERICARDIUM

See also B S P, Vol 4, p. 412, S. Key 179.

Wounds of the heart

Deaths due to cardiac injury during intrathoracic surgery.—RUPRECHT and ADELMAN (1949) report 2 cases in which death resulted from unsuspected trauma to the heart during intrathoracic surgery as a warning against similar inadvertent cardiac damage and to

aspect of the left ventricle close to the apex. In the second case a pneumonectomy was being performed for a bronchiogenic carcinoma, but tumour surrounded much of the inferior pulmonary vein To

heart was retracted

well but suddenly cc

bruise of the left ver

in laboratory anima

similarly produced cases of cardiac contusion and suspect that some of the arrhythmias reported after pneumonectomy might be due to this cause. Usually other factors are cited—

vagal reflexes from the damaged lung-root, mediastinal shift or myocardial anoxia. Cardiac contusion may produce no symptoms or may cause altered heart sounds, systolic murmurs from dilated valvular rings, a variety of heart rhythms, congestive failure or the picture of coronary occlusion. Both the pathology of the lesion and the resulting electrocardiographic changes closely resemble those of myocardial infarction. Any patient who, following a thoracic operation, maintains an unexplained tachycardia or develops arrhythmia, a pericardial friction rub, chest pain, congestive failure or shock, should arouse a suspicion of cardiac injury. Prevention is the best treatment and prolonged rest in bed on expectant lines the best therapy, but quinidine may be desirable to prevent recurrence of an arrhythmia or to limit extrasystoles originating in the damaged myocardium.

Ruprecht, A. L., and Adelman, A. (1949). *New. Engl. J. Med.*, 241, 637.

HERNIA

See also B.S.P., Vol. 4, p. 428, S. Key 180

Inguinal hernia

Anatomy.—McVay (1948) presents a concept of the anatomical defect in the various [illegible] of repair used in 100 inguinal and femoral [illegible] 9 years after operation. In a small indirect [illegible] ion of the hernial sac and closure of the [illegible] ersus abdominis [illegible] er fascial layer [illegible] of aponeurotic [illegible]

for repair of the posterior inguinal wall is the same in all three types of hernia [illegible] Reinhoff's relaxing incision in the rectus sheath and excision of all thinned fascial and aponeurotic elements of the posterior inguinal wall. The repair consists in suturing the strong free margin of the posterior wall to Cooper's ligament from pubic tubercle to [illegible] of the femoral [illegible] rmatic [illegible] heath. [illegible] ecture [illegible] scular

power and function in the treatment of hernia. Originally Russell [illegible] ernal sac was essential before the abdominal wall could be penetrated—the Saccular Theory of Hernia—though he later withdrew this overstatement. Russell therefore removed the sac and interfered as little as possible with the muscles. Taylor points out that the modern tendency develops Russell's conceptions and aims at ensuring that the natural function of the inguinal canal is not destroyed by operative damage to muscular tissues. An oblique inguinal hernia is due either to the pre-existence of a sac or to the incontinence of the internal abdominal ring. The latter may result from many causes, one of which is the failure of normal muscular closure, as described by Lytle. The treatment in young subjects, with a [illegible] ac only, popularized in World [illegible] s not thus completely assessed; [illegible] ring closure is necessary. For [illegible] the fascia transversalis, which [illegible] feeble, the fascia frail and the

hernias
repair w
tendon
traced.

tubercle. A large internal ring is made to fit snugly around the cord All patients must be walking after 24 hours and the incision is then left without dressing Cases are discharged from hospital on the eighth post-operative day and return to work in 6 weeks, sedentary workers even earlier.

long a period A recurrence after an indirect hernia is usually direct unless the removal of the sac or the closure of the wound was faulty. With a Bassini type repair, however, recurrences usually occur through the opening left for the cord, or occasionally just above the pubis or through some weak spot in muscle, fascia or suture line. Recurrences after repair

normal movement of the fascia and muscles of the region. The Cooper ligament operation involves suture of the inferior aponeurosis of the internal oblique and transversalis muscles to Cooper's ligament This operation was suggested by Babcock in 1927 because the fascia

interrupted silk or cotton It is then notched to fit snugly around the spermatic cord and the upper edge fixed well up under conjoined tendon and internal oblique. A similar patch can be obtained from the skin after cutting away the epidermal layer with a skin-graft razor as popularized by Cannaday.

Ventral hernia

Hernia in the region of the umbilicus in infants.—BENSON, PENBERTHY and HILL (1949) describe their experiences with 7 cases of hernia in the region of the umbilicus in infants. They believe that the use of the term "omphalocele" in an all-inclusive manner has led to confusion in surgical treatment and evaluation of results. They consider that an omphalocele or amniocele should refer only to those congenital defects in which there is herniation of the

describe 3 such cases. One child, however, had also an atresia of the terminal ileum and despite a short-circuit anastomosis finally succumbed with mesenteric vascular occlusion. Similar closure of an omphalocele, however,
are present in the sac, produces such a tens
circulatory failure can occur within 48 hour
which the defect in the abdominal wall is considerable the correct procedure is to undertake a two-stage closure. This alone will reduce the mortality. The first stage involves resection of

the defect in layers and completely reducing the abdominal viscera. Concomitant intraperitoneal congenital abnormalities are of course common and the authors prefer that these should be observed and treated if desired at the first operation. This is in contrast to the method of Gross in which the amniotic sac is not opened but inverted to prevent adhesions and provide a stronger temporary abdominal wall. Four cases are described and in each there was some additional intraperitoneal anomaly. Despite the presence of liver in the sac in each case, which usually means a poor prognosis, only one died; a premature baby in which it was found impossible to approximate the skin over the herniated viscera.

A simple repair for umbilical hernias in infancy and childhood.—CAMPBELL (1949) describes a simple method of repair for umbilical hernia in infancy and young children. Cases selected are those in which strapping has failed and the opening is not more than 3 centimetres in diameter. A small incision is made down to the fascia ½ inch lateral to the fascial ring. The skin and subcutaneous tissue about the hernia are undermined by dissection with an aneurysm needle. No. 1 silk on a large curved needle is now passed through the incision and around the hernial aperture, a short distance from it, taking in the fascia in the manner of

Sliding hernia of the colon

Trans-abdominal operation.—BROWN (1949) describes a trans-abdominal operation for sliding hernia of the colon. He suggests that it should be suspected in cases with a large ring

Treatment

Whole-thickness skin grafts.—A study of 211 cases of inguinal, umbilical, femoral and incisional hernias treated by whole-thickness skin grafts is presented by ZAVALETA and
2·36 per cent, a figure
risk of intolerance or
ntly fixed, an essential
in obtaining quick atrophy of the epidermia and of the sweat and sebaceous glands. The method possesses the advantage of enabling the graft to be obtained directly from the zone

for 3 days prior to operation; the prophylactic administration of 200,000–500,000 units of penicillin, a few moments before the operation, is recommended. The graft, when taken, is kept in normal saline solution or local anaesthetic until used; this absorbs any adherent connective and adipose tissue. The graft should be placed on a bed of muscular tissue; the greater part of the bed, in inguinal hernias, is constituted by the transversalis fascia covering Hessert's triangle. After taut fixation, the graft is covered wherever possible by an aponeurotic layer, which should be sutured loosely over the graft. Penicillin may be applied before the skin is sutured, the use of sulphanilamide may give rise to serohaematic effusion. Modification of the technique is required in the different types of hernia. Included in the authors' series were 6 emergency cases of strangulated hernias, all of which healed without complications. The use of whole-thickness skin grafts is particularly indicated in cases with a tendency to recurrence, such as umbilical hernia in old and obese subjects.

Results of treatment

comprising 78
ventral hernia
included: gene

involved structures below skin level, the organisms cultured from the wound were

brain tumour, among the elective cases, and 8 among the emergency cases, the contrast forming a graphic argument for the elective use of surgical treatment. The anaesthetic recommended is 1 per cent Novocain block infiltration for inguinal, femoral and small

2 stages at about 12 days' interval.

Benson, C. D, Penberthy, G C, and Hill, E J (1949). *Arch. Surg, Chicago*, **41**, 833.
Brown, R. K (1949). *Surg Gynec Obstet*, **88**, 495.
Campbell, J P. (1949) *Amer J Surg*, **77**, 506
Jackson, P. P (1949). *J int Coll Surg*, **12**, 497

Gynec. Obstet., **91**, 157.

HERNIA—DIAPHRAGMATIC

See also B S P, Vol. 4, p 451, S. Key 181

Aetiology and classification

Traumatic hernias of the diaphragm—STOCKER (1948) discusses traumatic hernias of the diaphragm in contrast to congenital hernias or acquired para-oesophageal hernias. Anatomically the traumatic hernia, which may arise as a result of open or closed injury, is not a true hernia in that the abdominal viscera prolapse into the thoracic cavity through a hole in the diaphragm without an intervening covering of peritoneum. The prolapse is the result of the disparity between intra-abdominal and intrathoracic pressure. The author gives an account of four such cases

viscera through the umbilical and supra-umbilical portions of the abdomen into a sac covered by peritoneum and amniotic membrane. With wide separation of the recti muscles and fascia an omphalocele thus presents a formidable problem In contrast a hernia into the umbilical cord has a defect limited to the umbilical opening which is practically always less than 4 centimetres in diameter. This latter condition allows resection of the sac, replacement of viscera into the peritoneal cavity and closure of the defect in layers. The operation should be undertaken within a few hours of birth and before the amniotic sac ruptures. They describe 3 such cases. One child, however, had also an atresia of the terminal ileum and despite a short-circuit anastomosis finally succumbed with mesenteric vascular occlusion. Similar closure of an omphalocele, however, in which much more of the abdominal viscera *are present in the sac, produces such a tension within the abdomen that respiratory and* circulatory failure can occur within 48 hours. The authors believe that with any case in which the defect in the abdominal wall is considerable the correct procedure is to undertake a two-stage closure This alone will reduce the mortality. The first stage involves resection of

the defect in layers and completely reducing the abdominal viscera Concomitant intraperitoneal congenital abnormalities are of course common and the authors prefer that these should be observed and treated if desired at the first operation. This is in contrast to the ... prevent adhesions ... nd in each there ... r in the sac in each case, which usually means a poor prognosis, only one died; a premature baby in which it was found impossible to approximate the skin over the herniated viscera.

skin and subcutaneous tissue about the hernia are undermined by dissection with an aneurysm needle. No 1 silk on a large curved needle is now passed through the incision and around the hernial aperture, a short distance from it, taking in the fascia in the manner of

the usual way. The author reports uniformly successful results.

Sliding hernia of the colon

Treatment

Whole-thickness skin grafts.—A study of 211 cases of inguinal, umbilical, femoral and ... presented by ZAVALETA and ... per cent, a figure ... of intolerance or of formation of cysts of the epidermis is eliminated in the graft ... red, an essential ... atrophy of the epidermis and of the sweat and sebaceous glands The ... few

a tendency to recurrence, such as umbilical hernia in old and obese subjects

Results of treatment

Hernias in aged people.—STRENGER (1949) reviews the results of the surgical treatment of hernia in the aged. Operation was performed on 82 patients over 60 years of age, of whom 70 were males and 12 females. The series included 20 emergency cases, one woman with an incarcerated femoral hernia was 102 years old. A total of 95 operations were performed,

Standard techniques were used There were 5 cases of wound infection Only one of these involved structures below skin level; the organisms cultured from the wound were *Staphylococcus albus* and *Bacillus coli* A prompt response to sulphonamides and penicillin was noted There were 13 cases of broncho-pneumonia, 2 of posterior crural phlebitis, and 1 of epididymitis, and 1 of fatal shock One patient had a cerebral accident on the sixteenth post-operative day, and one man with cirrhosis had a massive gastro-intestinal haemorrhage; there was no case of pulmonary embolus There was 1 death, from a cerebral accident and brain tumour, among the elective cases, and 8 among the emergency cases, the contrast forming a graphic argument for the elective use of surgical treatment. The anaesthetic recommended is 1 per cent Novocain block infiltration for inguinal, femoral and small umbilical hernia, supplemented if necessary by inhalation of cyclopropane and oxygen Silk should be used, rather than catgut, and the utmost care taken in the treatment of tissues Orchidectomy may be done if the patient agrees and if absolutely necessary for the security of the repair. In cases of bilateral inguinal hernia, the operation should be performed in 2 stages at about 12 days' interval.

Benson, C. D , Penberthy, G. C , and Hill, E. J (1949). *Arch. Surg , Chicago*, 41, 833.
Brown, R. K (1949). *Surg. Gynec. Obstet.*, 88, 495.
Campbell, J. P (1949). *Amer. J. Surg.*, 77, 506.
Jackson, P. P. (1949). *J. int. Coll. Surg* , 12, 497
McVay, C B. (1948) *Arch Surg , Chicago*, 57, 524.
Strenger, G (1949) [illegible]
T [illegible]
W [illegible]
Z [illegible]) *Surg Gynec Obstet.*, 91, 157.

HERNIA—DIAPHRAGMATIC

See also B S P., Vol 4, p. 451, S. Key 181.

Aetiology and classification

Traumatic hernias of the diaphragm.—STOCKER (1948) discusses traumatic hernias of the diaphragm in contrast to congenital hernias or acquired para-oesophageal hernias. Anatomically the traumatic hernia, which may arise as a result of open or closed injury, is not a true hernia in that the abdominal viscera prolapse into the thoracic cavity through a hole in the diaphragm without an intervening covering of peritoneum. The prolapse is the result of the disparity between intra-abdominal and intrathoracic pressure. The author

a rent in the left side of the diaphra...

was later enlarged by excessive intra-abdominal pressure during exercise.

As a contrast to these two cases the author describes two cases of war wounds of the left side of the chest ...

hole in the diaphragm for its pedicle, the other organs being reduced.

Differential diagnosis

Differential diagr... record their inves... coronary artery dis... may be coexistent. ... ing complete clinical examinations, a series of 57 patients with positive x-ray evidence of ...

in 3 cases in whom cardiac symptoms alone presented, the authors stating that diaphragmatic hernia would probably never have been suspected by the histories alone. A final group of 10 cases of associated anaemia, with haemoglobin between 20 and 60 per cent, as the result of chronic haemorrhages from the stomach, showed symptoms of coronary ...

... assessed.

Master, A. M., Dack, S., Stone, J., and Grishman, A. (1949). *Arch. Surg., Chicago,* 58, 428.
Stocker, H. E. (1948). *Wien med. Wschr.*, 98, 545.

HYDATID DISEASE

See also B.S.P., Vol. 5, p. 46, S. Key 187.

Treatment

Operative removal of univesicular pulmonary hydatid cyst.—BARRETT (1949) describes a technique for the removal of a simple univesicular pulmonary hydatid cyst. The patient is given a general anaesthetic, and an air-tight circuit is made by the introduction of a cuff-tube into the trachea. Th... the cyst rupture into the bro... intercostal incision ... which may be present are divided, in order to free the lobe containing the cyst. The affected lobe, or the cyst if it be a large one, is then enclosed in a bag of thin mackintosh, resembling

bag is placed of the lobe brought out through the incision and spread out on the surface of the wound. The lung is incised down to the adventitia, which is partially opened by an incision placed towards the bottom of the cyst, the patient lying c the adventitia, and no atter the surgeon is now finished the cyst has been extruded. pressure in the anaesthetic circuit so that gradually, over 10–30 minutes, the adventitia cracks and the intact hydatid falls slowly out of the lung and comes to lie in the mackintosh bag. The operating table is then tilted towards the surgeon, so that, by tightening the lower margin of the bag, the cyst may be lifted to the surface. The method described by the author in earlier papers is then used to deal with the empty "sac" in the lung

Barrett, N. R (1949). *Lancet*, 2, 234.

INTESTINES

See also B.S P., Vol. 5, p 148, S. Key 198.

Regional ileitis

Survey of literature and report on 34 *cases of Crohn's disease* —ARMITAGE and WILSON (1950) survey the literature on Crohn's disease and report on 34 cases In these cases the terminal ileum was affected in 30, the colon in 13 and the jejunum in only 1 In a follow-up of cases of "acute terminal ileitis", no evidence was found to suggest that it ever became chronic or was an early stage of Crohn's disease The wall of the terminal ileum is thickened and rigid, and small whitish "tubercles" are commonly seen on the serous surface The transition from diseased to healthy bowel is usually abrupt Mucosal ulceration is usually present Submucosal thickening and fibrosis of the muscular layers produce narrowing of the lumen. A specific histological change is an endothelial-cell proliferation in the submucous lymph-follicles and the appearance of giant cells in their centres These follicles do not caseate and acid-fast bacilli are not found in them Clinically there were four chief groups of cases· (1) acute intra-abdominal disease with peritoneal irritation; (2) ulcerative enteritis; (3) chronic small-bowel obstruction, (4) persistent and intractable fistulae. The chief symptoms were pain, diarrhoea, loss of weight and a palpable mass Of special

special reference to tuberculosis, reticulosis, lymphatic obstruction, virus infection and psychosomatic factors. The incidence of hyperplastic intestinal tuberculosis and of Crohn's disease was compared over the past 25 years. The authors conclude that cases formerly diagnosed as hyperplastic intestinal tuberculosis are now called Crohn's disease.

Armitage, G , and Wilson, M. (1950). *Brit J Surg* , 38, 182

INTUSSUSCEPTION

See also B S P., Vol 5, p. 160, S. Key 200.

Aetiology and treatment

just proximal to the hepatic flexure After a minute the barium passed on to the caecum and terminal ileum. The ileum appeared incompletely filled which suggested the possibility of intussusception. On examination of the radiographs, the pitchfork sign, diagnostic of

under the influence of abnormal stimuli Aberrant pancreatic tissue is an uncommon condition Only 430 cases were reported up to 1944. At the Mayo Clinic the incidence was 1 7 per cent at routine autopsies over a 5-year period. Seven recorded intussusceptions were associated with pancreatic tissue.

Keeley, J. L. (1950). *Arch. Surg., Chicago*, 60, 691.

KIDNEY AND URETER—GROWTHS

See also B S P., Vol. 5, p. 268, S Key 210.

Aetiology, diagnosis and treatment

Ureteral tumours—HAMM and LAVALLE (1949) discuss the aetiology, diagnosis and treatment of tumours of the ureter. Ureteral tumours are uncommon, but the authors have records of 6 cases from Brooklyn Hospital, 4 of which they personally investigated and treated. In the records of 2,407 necropsies at the hospital they found no mention of ureteral tumour. Of the 4 cases described in detail the first was a pregnant woman aged 20 years with a history and urinary findings suggestive of calculus Cystoscopy revealed a polypoid mass at the ureteral orifice. Nephrectomy was performed and the ureter removed. The tumour, the cells of which represented an ectopic decidual reaction, originated in the lower segment of the ureter Abortion occurred, but it is interesting to note that the woman became pregnant again and was successfully delivered within eighteen months of the operation The second case was a female aged 59 years and the symptoms included frequency, haematuria and pain in the loin. Nephrectomy and ureterectomy were successfully carried

another hospital but the tumour was located in the stump of the corresponding ureter. The growth was a villous papillary carcinoma which had grown through the ureteral wall and invaded the surrounding tissues The ureter was removed but the patient died within 6 months of generalized carcinomatosis The authors, discussing the diagnosis, say there are [illegible] stage. Pain and frequency of micturition are common [illegible]. They [illegible]gnosis [illegible]nales; [illegible] about 50 years; and 75 per cent of tumours occur in the lower third of [illegible]m, is potentially [illegible]nd ureterectomy [illegible] Tumour

[illegible] between the years 1931 and 1947 to the Babies' Hospital, New York, are briefly [illegible]

living, and 4 of these have survived operation for sufficiently long to be considered cured. The others are too recent to be assessed Eight died of metastases within 39 months of operation, the earliest post-operative death being after one month All these cases received radiation therapy to the operative site or to the metastases. Many of the cases in the series received pre-operative or post-operative radiation, or both. Of 6 of those receiving pre-operative radiation 5 died, and the tumour of the sixth increased in size during the treatment. Another developed metastases, preventing operation. The authors conclude that operation should be carried out as soon as the diagnosis is made, without pre-operative radiation Although the 4 patients in the series who survived more than 3 years from operation did not have post-operative radiation, the authors have used it, nevertheless, during the past 2 years, as they are impressed by some reports of long survival in inoperable cases which have received radiation therapy only. They irradiate the operative area with a minimum of 1,000 r within a month, and irradiate metastases as they occur.

Hamm, F. C , and Lavalle, L L (1949). *J Urol*, 61, 493.
Hazzard, C T., Melicow, M. M , and Seidel, R F. (1949) *N.Y. St J. Med*, 49, 649.

KIDNEY AND URETER—HYDRONEPHROSIS AND PYONEPHROSIS

See also B S P , Vol. 5, p 286, S. Key 211

Special aids to diagnosis

by abdominal compression from above, or by the combination of both It is essential to restrict movements of the organ due to respiration This is achieved by introducing two small-calibre needles through the renal parenchyma in the region of the lower and middle calyces respectively Puncture can only be effected with an immobilized and distended pelvis, confirmed by the x-ray screen The needle should enter the posterior wall, avoiding the renal vessels, near the lower end of the pelvis where physiological contractions will be least hindered The technique allows for the collection of urine for examination Transpelvic

needle may be introduced through which to establish pneumo-kidney. The various radio-manometric investigations may be accompanied by compression of the ureter or occlusion of the upper ureteric meatus The lower urinary tract may be studied, without such urinary obstruction, including all stages of activity of the bladder

Operative technique

Plastic repair of retrocaval ureter.—A case of retrocaval ureter with successful plastic repair is reported by SHEARER (1949). A white woman, age 24 years, was admitted to hospital with a history of recurrent chills and fever and attacks of right flank pain A congenital defect of the interventricular septum had been discovered at routine examination 2 years previously. Examination on admission revealed a large, tender mass in the right flank with deep tenderness to percussion over the right costovertebral angle Cystoscopy demonstrated right hydronephrosis apparently due to obstruction in the upper one-third of the right ureter. There were 100 millilitres of purulent residual urine in the right kidney; indigo carmine dye was excreted in 9 minutes with moderate concentration after 15 minutes. Retrograde pyelograms demonstrated a double kink in the upper one-third of the right ureter; the middle one-third lay over the spinal column At operation the ureter was found to pass between the aorta and the vena cava winding around posterior to the vena cava and entering the renal pelvis. The ureter was severed about 2 centimetres from the renal pelvis, passed beneath the vena cava and replaced anteriorly, the severed ends were anastomosed and the renal pelvis incised. A 5F ureteral catheter was passed down the ureter to the bladder and the proximal end brought out of the pyelostomy wound A 20F mushroom catheter was placed in the renal pelvis which was closed with catgut. Nephropexy was then

done and the flank wound closed. Uneventful recovery followed
5 months showed tha
tance in these cases c

Kapandji, M. (1949). *Bull. Soc. méd. Hôp., Paris*, 65, 849.
Shearer, T. P. (1949) *J. Urol.*, 62, 152.

KIDNEY AND URETER—STONE

See also B.S P., Vol. 5, p. 297, S. Key 212.

Incidence

Occurrence of vesical calculus in Norfolk.—RIDLEY THOMAS (1949) reviews the historical evidence c
century. T
period at
1921–38,
points were demonstrated; vesical calculus in the first two decades of life disappeared between 1910–30, coinciding with a raised standard of living and a change to mixed farming in Norfolk. This supports the theory of the part played by vitamin A deficiency in calculus formation; in the fourth and fifth decades there was a drop probably due to earlier recognition of obstructive and infective lesions; there was a considerable reduction in the number of cases in the later years of life From an analysis of the cases admitted during the periods 1929–38 and 1943–47 it was seen that in the former about 50 per cent had no obvious underlying urinary pathology and recurrences occurred in 7 per cent; of the second group only 10 per cent were unaccounted for and recurrences were nil. The author concludes that vesical calculus is no longer common in Norfolk.

Ridley Thomas, J. M. (1949). *Brit. J. Urol.*, 21, 1.

LARYNX—SURGICAL DISEASES OF

See also B.S.P., Vol. 5, p. 338, S Key 216.

Inflammatory diseases

Streptomycin in the treatment of scleroma.—According to ĆURKOVIĆ (1950), scleroma is endemic in Yugoslavia. Treatment by surgery, diathermic coagulation and radiotherapy
period
rough,
rations
iglottis
as a flat
infiltration on the anterior laryngeal commissure. The ventricular ligaments were red and
The tracheal mucosa was red and covered partly
The diagnosis of scleroma was confirmed histo-
by diathermy coagulation. Penicillin, 4,500,000
streptomycin, 35 grammes, were given during a
When seen again 6 months later she appeared to
be well. The second patient was a man, age 22 years, whose father and sister had scleroma. He had been hoarse for 2 years. His disease extended into both main bronchi as well as into the nose, pharynx, larynx and trachea. He was given daily 300,000 units of penicillin, 5 grammes of sulphonamide and 1·5 grammes of streptomycin. *Half a gramme of* streptomycin was injected through a tracheotomy cannula on alternate days in addition to
after a further

Operative treatment

Indications for a preliminary tracheotomy.—Surgical patients likely to need tracheotomy
with obstruction is best dealt with by a preliminary formal tracheotomy.

injury or from laryngeal nerve involvement. Obstruction may be urgent, severe and complicated by haemorrhage and infection. These cases are often difficult to deal with: the best results are obtained by doing a preliminary tracheotomy.

Ćurković, M (1950) *Arch Otolaryng., Chicago*, 52, 253
Friscia, P, and Bishop, H. F. (1949). *N Y. St J. Med*, 49, 1550.

LUNG—TUMOURS

See also B.S.P., Vol. 5, p 450, S Key 225.

Carcinoma

Cardiovascular disturbances in bronchial carcinoma—MOLL (1949) studied a series of 114 cases of bronchial carcinoma proved at necropsy in an attempt to discover the nature of the cardiovascular disturbance which so often leads to post-operative death, the relation

was present; in 78 per cent of these it was serous, in 16 per cent haemorrhagic and in 6 per cent purulent. Tumour cells were never found in sputum or effusion The correct diagnosis

empyema at necropsy. The case of a patient who apparently had an untreated bronchial

bronchial one.

Diagnosis—The silent phase of cancer of the lung is discussed by OVERHOLT and SCHMIDT (1949). Statistics show that only a small number of patients can be helped by thoracic surgery The authors found, in a series of 721 patients, that only 9 per cent presented themselves for treatment when the growth was still confined to the lung. The delay in diagnosis results from 4 main causes: (1) cough is usually the first and only symptom, (2) abnormal physical signs on auscultation are absent or are not characteristic; (3) secondary infection, frequent during the symptom phase, may lead to misdirected treatment, and (4) wide variations of densities in the conventional skiagram depending on the relative position and superimposition of the aerated to unaerated segments. The mass-survey method of tuberculosis case-finding has reversed the ratio of minimal to advanced cases, and may be similarly useful in cases of cancer; the highest yield of silent cancer will be found among males aged 45 years or over Screening of the whole population and prompt and adequate investigation of suspected cases are of equal importance. The information may be supplemented by: (1) positional stereoscopic tomograms; (2) cytological examination of sputum; (3) bronchoscopy, and (4) exploratory thoracotomy. The possibility of cancer is not excluded by negative results of sputum examination or bronchoscopy. Surgical exploration should be advised in doubtful cases, and direct biopsies can then be made of lesions near the surface and of many in the hilar area.

Incidence of metastasis of lung tumours to the brain.—The incidence with which carcinoma of the lung metastasizes to the brain has been variously given as from 16 5 per cent to

36 3 per cent, an average figure being 23 per cent. The

and Jacksonian ac
the right fronto-p
mass of increasec
including an arteriogram and a pneumoventriculogram, an osteoplastic craniotomy was performed in the right fronto-parietal region A firm nodule of carcinoma was found deep to a subcortical cyst in the region of area 4 and was extirpated together with the oedematous and necrotic tissue around it. There were no indications of any other metastatic lesion in the brain or elsewhere, and three weeks later right pneumonectomy was performed. There did not appear to be any extension of the lung carcinoma to the mediastinum or to lymph glands. Five months later there was no recurrence of the pulmonary carcinoma of the cerebral metastasis. The authors feel that craniotomy is indicated when there appears to be only one well-localized intracranial lesion, whether or not the primary tumour can be reached; and that this procedure should precede the attack on the primary lesion. Pneumonectomy should be reserved for those cases in which there is reasonable hope of cure.

Ballantine, H T., Jun., and Byron, F X. (1948). *Arch. Surg., Chicago*, **57**, 849.
Moll, A (1949). *Dtsch. Arch klin Med.*, **194**, 530.
Overholt, R H , and Schmidt, I. C. (1949). *J. Amer. med. Ass* , **141**, 817.

MENINGES—MENINGITIS, ACUTE AND CHRONIC

See also B.S P , Vol. 6, p. 69, S. Key 233

Treatment

Surgical aspects of meningitis.—CAIRNS (1949) discusses the surgical aspect of meningitis.
open head wounds or
rmerly employed for
of cerebrospinal fluid
hs with physiological
fluids. The use of Flexner's meningococcal serum had some success Since the advent of penicillin in 19
blood-cerebro
has also been
good levels of
introduction Cairns points out that the brain tissue is relatively resistant to bacterial infection, whereas the ventricles and basal cisterna are much more affected. The degree of intellectual recovery after the most intense meningitis is astonishing. The rise of intracranial pressure which occurs in any acute meningitis is not an important cause of symptoms in the early stages but may become so later. In meningitis any part of the cerebrospinal pathways may become blocked, especially the foramen of Monro, the aqueduct of Sylvius, the foramina of Luschka and Majendie, the cisterna ambiens and the spinal canal, which prevents the passage of antibiotics from the ventricles
and vice versa. These obstructions may be complicated
through the foramina. Operation may be undertake
(*a*) to prevent meningitis, (*b*) to aid rapid diagnosis, (
relieve obstruction and intracranial pressure. Usually c
becomes necessary.
burr-holes for
and adjacent
the cerebro-
stage or by
complicated
progressing
r injection of
streptomycin has proved of great value in a small proportion of cases, and Cairns believes that frontal burr-holes should be made at the commencement of streptomycin therapy in

rise of intracranial pressure. He concludes that surgery has a valuable

of meningitis, but must always remain subservient to the main problem, which is one of bacteriology and chemotherapy.

Cairns, H. (1949). *Brit. med. J.*, 1, 969.

MUSCLE AND TENDON—DISEASES AND INJURIES

See also B.S.P., Vol. 6, p. 128, S. Key 235.

Diseases of muscle

The latissimus dorsi as a replacing muscle.—Loss of the use of the triceps is particularly

in line with the long head of triceps, and fixed to the triceps aponeurosis with interrupted non-absorbable stitches. Care must be taken to avoid the radial nerve which lies anterior

operated on for a triceps paralysis showed some degree of extension against gravity three and a half weeks after operation following the removal of the cast; 18 months after, he had a range of movement and power equal to the other arm

Harmon, P H (1949). *J. Bone Jt Surg.*, 31A, 409.

NECK—CUT THROAT

See also B.S.P , Vol. 6, p 173, S Key 237.

Aetiology and treatment

Fracture of hyoid bone.—The forensic importance of fracture of the hyoid bone by direct violence is well known. OLMSTEAD (1949) in a review of the literature draws attention to the less well appreciated fracture by indirect violence due to the muscular action of forcible swallowing or sudden hyperextension of the neck and illustrates each type of case by an example from his own experience Normally the hyoid is well protected by its flexibility and mobility so that even fracture by direct violence is rare. In the first case

X-ray examination showed a transverse crack in the greater cornu about 0 5 centimetre from the junction of cornu and body. On account of the dysphagia the patient was fed by tube and cold packs were applied to the swelling which subsided in 5 days Olmstead believes that the fracture was caused by manneristic hyperextensive movements of the neck to which the patient was prone The second case is a straightforward example of fracture of the hyoid by direct violence due to attempted suicide by hanging, the bone being fractured in the middle of the left greater cornu with angulation of the posterior fragment. Treatment depends largely on whether or not the larynx or pharynx has been perforated. If perforation has

muscular action.

Olmstead, E G. (1949) *Arch. Otolaryng , Chicago*, 49, 266.

NECK—CYSTIC SWELLINGS OF

See also B S.P., Vol. 6, p 178, S. Key 238.

Lateral developmental cysts

Causation and treatment of branchial cysts.—McLAUGHLIN (1948) refers to the literature concerning branchial cysts and concludes that their causation is not yet settled. They are

the most common cause of a single swelling in the lateral aspect of the neck, and although congenital in origin they usually appear in early adult life. Case 1. A pregnant woman developed a cystic mass 5 centimetres in diameter in the upper cervical region and the ...

be incised again. Excision was carried out 6 weeks later without difficulty. In contrast with branchiogenic cysts, sinus tracts of similar origin are present at birth or appear in early life, often as a small dimple just above the clavicle. Complete fistulas open externally above the clavicle and internally into the pharynx near the lower portion of the tonsillar fossa, and they are the commonest form. Incomplete fistulas have only the external or internal opening. The principal symptoms associated with a complete fistula are a draining sinus, intermittent swelling in the neck, dysphagia, drainage into the pharynx with a peculiar taste in the mouth, retraction of the external opening on swallowing and odour from the external discharge. Surgical excision by the technique described by Bailey is the method of choice and the operation is described in detail. Excellent results without recurrence are to be expected.

McLaughlin, C. W. (1948). *Arch. Surg., Chicago*, 57, 450.

NEOPLASMS—INNOCENT AND MALIGNANT

See also B.S.P., Vol. 6, p. 194, S. Key 240.

Treatment

Modern methods of treating malignant disease.—Although the general mortality trend for ... end trend in the mortality rate during the past decade ... urvey of ... that the ... ich can ... eatment of ... itation and ... the cancer and the hospital which accepts ... atic ... ose ... ing ... nce ... iod ... ing ... ble ... tes ... the ... eir ... accessible group and there ... attention to the curable treatme... cancers ... pation ... over-all cure rate.

Garland, L. H. (1949). *Amer. J. Roentgenol.*, 62, 858.

NERVES, PERIPHERAL—INJURIES

See also B.S.P., Vol. 6, p. 218, S. Key 242.

Results of surgical treatment

End-results of peripheral nerve suture.—SUNDERLAND (1949) presents a detailed review of the end-results of 61 cases of peripheral nerve suture. The painstaking observations and ... made over 6 years form the basis of this personal series in which motor and sensory ... able muscle contraction ... orded wasting. Standard ... iblish clinically. Factors ... red. Sunderland does not ... vourable, believing that

results Recovery may be delayed after nerve suture for many reasons so that there is good reason for not re-exploring to re-suture before 7 months (5 months for the median at wrist level). The only justification for earlier re-exploration is disruption at suture line, recognized by radio-opaque suture material or suspected because of faulty technique or unfavourable conditions, particularly tension. He also claims that unless recovery was

preparation for suture, nerve-ends must be cleanly trimmed of scar-tissue, and dissecting spectacles are necessary to determine when normal funicular bundles are reached, as revealed by the quality of the connective tissue and not necessarily the quantity, which latter varies throughout the length of a nerve. He believes neuromas are formed of sprouting axons and Schwann outgrowths and that the presence of a neuroma on an injured nerve or suture-line is not necessarily a sign that recovery will not occur, and that the absence of a neuroma is no proof that the nerve has not been severed. Mobilization to 20 centimetres does not

Sunderland, S. (1949). *Aust. N.Z. Surg.*, 41A, 264.

NEURALGIA—TRIGEMINAL, GLOSSOPHARYNGEAL

See also B.S.P., Vol. 6, p. 251, S. Key 243.

Treatment

Schlosser and improved upon by Haertel and others, and (2) the horizontal or trans-zygomatic route first used by Lévy and Baudouin The former needs more experience and

bar may be very strong and heavy so that one cannot see the foramen ovale in a dry skull from the lateral view. Even if so thin that one can see the foramen ovale through it, the passage of a needle into the foramen by the trans-zygomatic route would be a physical

impossibility. Chouké also adds that the presence or absence of another anomaly in the same region, namely the foramen pterygospinosum of Civinini, offers no barrier by either route to a needle directed towards the foramen ovale.

Chouké, K. S. (1949). *Amer. J. Surg.*, 78, 80.

NOSE, NASOPHARYNX AND ACCESSORY SINUSES

See also B.S.P., Vol. 6, p. 271, S. Key 244.

Infections of the nasal accessory sinuses

Diagnosis and treatment of mucocele of the sinuses.—TAMARI and O'NEIL (1949) describe four cases of mucocele of the sinuses and discuss the problems of diagnosis and treatment. They present a new theory of causation based on the pathological findings in their cases which appear [illegible]
haemorrhage [illegible]
a herniation o[illegible]
mucosa of one [illegible] pressure is there exerted with the production of characteristic changes which involves the underlying bone. The contents of a mucocele consist of old blood elements, erythrocytes, fibrous material and large cells. There are no cholesterol crystals, as a mucocele is of mesodermal origin; cholesterol crystals are found in such ectodermal growths as dental cysts. With pressure the mucosal cells lose their cilia and change from columnar to cuboidal. The cyst wall has an internal fibrous layer and an external epithelial layer; it is thicker at the base of the herniation but thinned out elsewhere. Bony changes are the result of pressure and tension and show recent absorption and osteoclastic activity. The treatment recommended is a radical operation with an external approach. If a horizontal incision is used to enter the frontal sinus the scar may be hidden by the regrowth of the clipped eyebrow The maxillary sinus is reached by the Caldwell-Luc method. Three of the four cases made uneventful recoveries after operation. The fourth case proved to be a carcinoma. The writers describe the [illegible]

the characteristic egg-shell crackling on pressure.

Tamari, M. J., and O'Neil, J. J. (1949). *J. Laryng.*, 63, 1.

ODONTOMES AND EPITHELIAL CYSTS

See also B.S P., Vol. 6, p. 302, S. Key 245.

Epithelial cysts of the jaws

Diagnosis and treatment of maxillary cysts.—SAGE (1949) describes the diagnosis of maxillarycysts. These cysts are not uncommon and are usually met by oto-laryngologists and dentists. [illegible]

whether the cyst is radicular or dentigerous.

Sage, R. (1949). *Ann. Otol., etc., St. Louis*, 58, 1068.

OESOPHAGUS

See also B.S.P., Vol. 6, p. 314, S. Key 247.

Rupture

Treatment of perforations: report of a case.—TEMPLE (1949) discusses the treatment of [illegible] of the oesophagus. The most common cause of perforation is tearing by

[illegible]

suggests that conservative treatment may be adopted for suspected damage to the cervical

[illegible]

Mediastinitis due to perforation of the oesophagus—HOMB (1948) gives an account of mediastinitis due to perforation of the oesophagus, and describes 3 cases successfully treated by combined chemotherapy and surgery. Apart from cases of cancer, in which the perforation is usually terminal, the most usual causes are the trauma of foreign bodies or

[illegible]

able than thoracic, and early treatment gives better results than late. In Homb's three cases, penicillin and sulphonamides were supplemented by mediastinotomy and pleural paracentesis. Penicillin failed to check the progress of inflammation following large perforations, but chemotherapy was valuable in keeping infection within moderate limits.

Carcinoma

Operative treatment of oesophageal carcinoma—NISSEN (1949) sums up the present position of radical operative treatment of oesophageal carcinoma, with emphasis on the technical details of operation. The procedure of choice is resection with oesophago-gastrostomy. An accurate knowledge of the blood supply of oesophagus and stomach is essential for success. Those vessels approaching the stomach from the left [illegible]

[illegible]

(*a*) abdomino-thoracic, *only useful for* cases in which gastric carcinoma has invaded the oesophagus; (*b*) thoracic, [illegible]

[illegible]

approach, tumours in the upper third of the oesophagus may also be resected successfully. Such a case is described.

Constriction

[illegible]

in all cases and showed a marked resemblance to those observed in cases of double aortic arch. Examination showed the aortic mass to the right of the midline, an indentation of the barium-filled oesophagus seen on the right side of the oesophagus in antero-posterior and left anterior oblique views, and a small defect posteriorly produced by the ligamentum arteriosum as it passed behind the oesophagus from the left side. A shallow extrinsic pressure defect was seen on the right side of the trachea. Complete relief of stridor and dysphagia followed surgical exploration with division of the ligamentum arteriosum and freeing of the vascular structures, these cases are believed to be the first instances of this procedure. The anomaly most likely to be confused with this condition is double aortic arch particularly [illegible]

493.

OMENTUM

See also B.S.P., Vol. 6, p. 354, S. Key 248.

Torsion

Diagnosis and treatment.—PUDERBACH (1949) discusses torsion of the omentum. The condition may simulate any one o[illegible] kept in mind in any case in whic[illegible]

[illegible]

is not definitely known, has been attributed to rotation of the heavy, fat-laden omentum about the larger vessels in its substance. It occurs usually in obese patients; a history of sudden trauma or unusual exertion is seldom elicited. Secondary torsion results from twisting of the omentum about its axis when the distal end is fixed by adhesions to an

records 3 cases, 2 of primary and 1 of secondary torsion.

Puderbach, W. J. (1949). *N.Y. St. J. Med.*, 49, 1571.

ORBIT—INJURIES, INFECTIONS, NEOPLASMS

See also B S P., Vol. 6, p. 369, S. Key 250.

Tumours of the orbit

Tumours of the orbit.—The possibility of improving treatment of orbital tumours has

cranially. Dissection close to the tumour in its capsule, to save ocular function, is thus possible under direct vision. Within the orbit the anatomic structure of the soft tissues forms three divisions The subperiosteal, the intramuscular and the space between the two. In the intramuscular zone tumours of the optic nerve and its sheath and endotheliomas predominate, while in the subperiosteal zone osteomas predominate Over a period of 40 years in the Mayo Clinic there were 3,190 patients with tumours of the eye or adnexa or both, of whom 740 had tumours of the orbit, 420 were operated on and, in the years 1937–47,

malignant melanomas, in which melanotic pigment remained after operation, but there has been no further spread. Haemangiomas usually occur in the middle division of the orbit In the 3,190 eye tumours, 205 were angiomas and 64 were located in the orbit. Thirty-three were haemangioma-endotheliomas, often confused with the highly malignant dural endotheliomas The greater number of vascular tumours are made up of proliferating small vessels with masses of fibrous tissue. Cavernous angiomas also occur, usually in children. These latter tend to recur after surgery, since they cannot be entirely removed.

Benedict, W. L. (1949). *Amer. J. Ophthal.*, 32, 763.

ORTHODONTICS

See also B.S P., Vol. 6, p 380, S. Key 251.

Treatment

Trends in orthodontic treatment.—Modern trends in orthodontic treatment in children are reviewed by PRINGLE (1950) Treatment is aimed as far as possible at the correction of

mal-relations and malformations of the dental arches and abnormal oro-muscular behaviour. Principles of orthodontic treatment could be stated as follows: every tooth and every dental arch is in a position of equilibrium between the forces acting on it, those of eruption and those of occlusion. The development, size, form and relations of the basal bones are controlled almost entirely by hereditary and general causes, and cannot be changed by orthodontic appliances. The introduction of cephalometric radiography has enabled a serial study to be made of any part of the facial area. The development, size, form and relations of the dental arches are controlled by general forces, but can be altered greatly by local pressures. In the last 20 years the changes occurring in occlusion from infancy onwards have been studied by means of plaster models. The most important local pressures on dental arches are: (1) oro-

(2) the habit of thumb and finger-sucking; and (3) the early extraction of deciduous teeth;
…ient teeth; vertical incisor overlap
…f the mandible is not uncommon.
…ffect being greatest in small and
…th are similar but more lasting.

Pringle, K. E. (1950). *Med. Pr.*, 224, 81.

PANCREAS

See also B.S.P., Vol. 6, p 433, S. Key 257.

Tumours

Heterotopic pancreatic tissue.—BUSARD and WALTERS (1950) discuss heterotopic pancreatic tissue. The recognition of this condition dates back to 1727, when Jean Schulz described it without the aid of microscopic confirmation, and to 1859 when Klob made the

Busard, J. M., and Walters, W. (1950). *Arch. Surg., Chicago*, 60, 674.

PARALYSIS—MANAGEMENT OF

See also B S.P., Vol. 6, p. 445, S. Key 258.

Treatment

Transplantation of spinal cord in paraplegia.—LOVE and ERB (1949) describe their experiences with transplantation of the spinal cord in the treatment of paraplegia. Five cases are

reported in detail. In case 1 a 28-year-old man developed paraplegia 13 years after treatment for a deformity of his spine. There was extreme kyphosis of the lower thoracic spine.

previously. Again a tuberculous extra-dural abscess was evacuated and a large bony ridge removed Eleven months later she was much improved and was allowed up fitted with a Taylor brace. Case 3 was a 13-year-old boy with a severe kypho-scoliosis due possibly to a birth injury or poliomyelitis in infancy; 2 years previously weakness and sensory loss commenced in the legs and bone graft fusion had been undertaken to correct his deformity. Complete spastic paralysis was present on examination and an x-ray after cisternal injection

vertebra was a hemivertebra. Elsewhere a laminectomy had been performed and the cord examined after the dura had been opened. A bone graft had then been inserted. The paraplegia, however, remained complete. Love re-explored the concavity of the scoliosis and

with paralysis of shortest duration. They also consider that streptomycin reduces the risk of such an exploration in a tuberculous process.

Love, J G., and Erb, H R (1949) *Arch. Surg , Chicago*, 59, 409

PARATHYROID GLAND—DISEASES

See also B S P., Vol. 6, p. 467, S Key 259

Hyperparathyroidism

Results of surgical treatment of hyperparathyroidism.—PARSONS (1949) discusses the results of operations for hyperparathyroidism A series of 32 cases comprised. 9 patients without calculi or renal impairment, 12 with calculi, or a history of renal calcification, 5 borderline cases with high normal nitrogen retention ... excretion rate; and 6 with serious renal in-

complained of vague pains before deformity ...

periods up to 12 years, indicate the importance of diagnosis and operation before the onset of skeletal deformity or renal damage that becomes irreversible.

Parsons, W. B. (1949). *Bull. N.Y. Acad. Med.*, 25, 285.

PEPTIC ULCER AND ITS COMPLICATIONS

See also B.S.P., Vol. 6, p. 496, S. Key 262.

Aetiology

Causation of peptic ulceration.—BEATTIE ([illegible]) reviews the classical aetiological factors [illegible]

[illegible] duodenal ulceration as in those suffering the late complications of gastrectomy or gastro- [illegible]

thoracic approach because the abdomen cannot be easily inspected, the neurectomy is *incomplete in 10 per ce*[illegible] this operation more da[illegible] operative insulin test-m[illegible] neurectomy there has b[illegible] *have healed within 4 months All but 2 psychotic cases have returned to normal diet and* full economic life. He has never had a case of ulcer recurrence. There was 1 death due to [illegible] from an aneurysmal dilatation of the right gastric artery lying beneath the [illegible]

parasympathetic stimulant, not yet on the market in Great Britain.

[illegible]

Treatment

Banthine in the treatment of peptic ulcer.—GRIMSON, LYONS and REEVES *(1950) believe* that Banthine (beta-diethylaminoethyl xanthine-9-carboxylate) is of value in the treatment of peptic ulcer. In cases of peptic ulceration with severe disability Banthine therapy may be sufficiently effective to obviate the need for surgical treatment. Either the methachloride or

[illegible] of the drug should be administered in a dosage of 100 milli-

stomal ulcer had symptoms which were severe enough to warrant surgical intervention, Banthine therapy was so successful that surgery was found to be necessary in only 5 instances Moreover, in most cases there was no need to supplement the treatment with other medicaments. It was also possible to dispense with conventional restrictions.

and pulse rate were observed continuously If bleeding persisted or the patient required repeated massive transfusions surgical intervention was immediately undertaken. If the patient recovered but had had several previous haemorrhages in spite of adequate medical regimen, the suitability for gastrectomy was considered. For purposes of treatment no classification of the cases was made, but for statistical purposes three groups were made.

picture changes, many being shocked on admission, but who showed good response to medical treatment. Group 3 comprised those patients who failed to respond to medical treatment and whose death seemed inevitable unless surgery was undertaken Of the 115 cases treated, 37 fell into group 1, 64 into group 2 and 14 into group 3

Surgical treatment of intractable duodenal ulceration.—Crile, Jones and Davis (1949) compare the immediate results of two series of cases treated surgically for intractable

anastomosis, afferent loop to lesser curvature, and a Hofmeister valve. The remaining 20 in the first group had a posterior gastro-enterostomy with the anastomosis in an isoperistaltic direction. These were the older patients with pyloric obstruction, technically difficult penetrating ulcers or poor operative risks In the second group the gastro-enterostomies were similar. The pyloroplasties consisted simply in the transverse suture of a longitudinal division of the pylorus. The authors consider the severity of the disease in each series comparable. The criteria for operation were identical and the same surgeons performed the operations. Since no case in the vagotomy series has been followed-up for more than 18 months the results in the earlier series have been limited to the same period. All later complications have been ignored. Those in the first series, however, were advised after

Vagotomy
Vagotomy
irst group.
vagotomy.

PEPTIC ULCER AND ITS COMPLICATIONS

See also B.S.P., Vol. 6, p. 496, S. Key 262.

Aetiology

Causation of peptic [illegible]

duodenal ulceration o [illegible]

incomplete in 10 per ce[illegible]
this operation more da[illegible]
operative insulin test-m[illegible]
neurectomy there has b[illegible]
have healed within 4 m[illegible]
full economic life. He has never had a case of ulcer recurrence There was 1 death due to haemorrhage from an aneurysmal dilatation of the right gastric artery lying beneath the ulcer crater 10 days after operation. This case had had no previous haemorrhage in the 5-year history. He believes that ether and curare as the anaesthetic reduces the post-operative chest complications and that prolonging the gastric suction in the post-operative period will prevent over-stretching of the stomach musculature and so reduce the number who develop unpleasant symptoms of gastric retention. This, and the intermittent diarrhoea and dumping syndrome which can occur, can be much relieved by "Urecholine", the latest American parasympathetic stimulant, not yet on the market in Great Britain

Hormonal overaction in relation to gastric secretion in chronic duodenal ulcer.—Discussing [illegible]

mucosal ulceration. The author performed high gastric resection in 3 cases of active gastro-jejunal ulceration, but severe pain persisted and there was an excessive amount of acid secretion. Accordingly a second operation was performed, and the pyloric antrum and the duodenal ulcer were excised. Considerable improvement resulted, for the major source of hormonal production had been removed. Many authorities regard peptic ulceration as a psychosomatic disorder; yet duodenal ulcers may occur in remarkably placid subjects. [illegible]und. As for the pathology of the [illegible] become adherent to the pancreas, [illegible] the common bile-duct. Surgical [illegible]op Gastro-jejunostomy produces excellent results in cases of duodenal stenosis. The operation is also performed in elderly patients debilitated by the effects of ulceration and in patients suffering from gastric stasis [illegible]

Treatment

Banthine in the treatment of peptic ulcer.—GRIMSON, LYONS and REEVES (1950) believe [illegible] of value in the treatment [illegible] nthine therapy may be [illegible] the methachloride or

the methabromide derivative of the drug should be administered in a dosage of 100 milli-

Banthine therapy was so successful that surgery was found to be necessary in only 5 instances Moreover, in most cases there was no need to supplement the treatment with other medicaments It was also possible to dispense with conventional restrictions.

picture treatment was begun, consisting of sedation as required, and hourly feeding of milk

patient recovered but had had several previous haemorrhages in spite of adequate medical regimen, the suitability for gastrectomy was considered. For purposes of treatment no classification of the cases was made, but for statistical purposes three groups were made

picture changes, many being shocked on admission, but who showed good response to medical treatment. Group 3 comprised those patients who failed to respond to medical treatment and whose death seemed inevitable unless surgery was undertaken. Of the 115 cases treated, 37 fell into group 1, 64 into group 2 and 14 into group 3

Surgical treatment of intractable duodenal ulceration.—CRILE, JONES and DAVIS (1949) compare the immediate results of two series of cases treated surgically for intractable duodenal ulceration. No case was subjected to operation unless medical treatment proved unsuccessful In the first series 87 patients were subjected to gastric resection or gastro-

anastomosis, afferent loop to lesser curvature, and a Hofmeister valve. The remaining

operations Since no case in the vagotomy series has been followed-up for more than 18 months the results in the earlier series have been limited to the same period. All later complications have been ignored. Those in the first series, however, were advised after

operation to have fre

whom vagotomy was

6 weeks after operati

vagotomy cases post-

reduces the mortality

reduces recurrence o ... the second group to 18 in the first group.

(3) Proved recurrent ulceration occurred in 3 cases in the first group, in 1 only after vagotomy.

in this group. They therefore claim that vagotomy gives better results at least for the first *18 months after operation.*

Vagotomy

Bilateral transpleural vagotomy with vagus resection—MORRISON (1949) describes in detail his technique for bilateral transpleural vagotomy with vagus resection for peptic ulcers, and discusses the criteria he considers desirable before undertaking this operation.

results both nerves and any communicating branches should be severed and excised. At operation he places the patient on the right side and under positive intratracheal anaesthesia the left chest is opened by subperiosteal removal of the seventh or eighth rib from the costal cartilage anteriorly to the transverse process posteriorly. The ligament of the lung is clamped doubly and tied off, retracting the lung upwards. The posterior mediastinum is

weight and can eat foods which were formerly forbidden.

normal mucosa (the criteria for the diagnosis of gastritis were those ... Schindler). Gastritis, however, shows unpredictable variations quite spontaneously, so that ... findings they consider questionable. Besides which, the pre-operative

s. In 4 of their

insulin tests.

Results of vagotomy in peptic ulcer.—WALTERS and FAHEY (1949) publish two series of cases in which vagotomy was performed by Walters The first series consists of 28 cases in ... undertaken during 1948, and the post-operative course of which was

it had vagotomy alone. A gastro-enterostomy had

on in 3 cases. Walters combined his vagotomy with

esection in 5 and with a pyloroplasty in 1 case.

of ulcer-pain, and the side-effects were negligible.

ult of the post-operative insulin test was negative.

... tube was used, and

one and
30 or mo
34 days.
formed b
death 10
examined personally and 26 answered *questionnaires*. The average period of review was 18 months. In 48 cases the results were excellent. In 9 cases ulcer symptoms were present

Gastrectomy

Partial gastrectomy for peptic ulcer.—PORTER and CLAMAN (1949) describe a series of

the possibility of retrograde influx into the proximal jejunal loop, but avoids leakage at the upper angle of the anastomosis They claim that the smaller stoma they advocate reduces three complications. These are: (1) leakage of the duodenal stump. This may result from faulty closure, but they agree with Alleson and Tintel that the commonest cause is an

Subtotal gastric resection and bilateral vagotomy for gastric and duodenal ulcers—An evaluation of gastric and duodenal ulcers for subtotal gastric resection and bilateral vagotomy is presented by MILLER (1950) Personal experience of nearly 1,000 resections has

operative period have been noted. Cases of persistent dumping syndrome show nutritional disturbances, but radiography or re-operation has not revealed recurrences; the author considers this condition to be of psychogenic origin, occurring in neurotics who, perhaps because of excess autonomic stimulation, developed ulcer secondary to a neurosis. Early vagotomies were performed by a transthoracic approach, but experience has shown that the morbidity is higher with a wide thoracotomy than with a simple laparotomy. The results from a small series of transthoracic and supradiaphragmatic vagotomies performed by various surgeons were much poorer than those from subtotal resection; these were, however, perhaps not all complete bilateral vagotomies. The author now uses vagotomy in all cases of stomal ulcer following subtotal resection and for some cases of ulcer recurring after a good functioning gastro-enterostomy; where the free hydrochloric acid reaches 90–100 units,

vagotomy is combined with subtotal resection, but resection has remained the standard procedure for gastric and duodenal ulcers. The subdiaphragmatic route is used, as this approach enables the diagnosis to be confirmed and adequate bilateral vagotomy to be performed, all the fibres can be felt by putting the stomach on the stretch after freeing the oesophagus. The chief problems have been gastric atony and diarrhoea; Wangensteen drainage is kept up for 5–7 days. Vagotomy should not be used for gastric ulcer, because of the frequency of mistaken diagnoses.

Partial gastrectomy: post-operative mortality and methods.—HOSFORD (1949) describes 200 consecutive cases of peptic ulcer, 107 duodenal, 83 gastric and 10 anastomotic, treated by partial gastrectomy from 1936 to 1947 with one death. The commonest causes of post-operative death are pulmonary infections, peritonitis from leakage, uraemia, embolus and haemorrhage. Twenty per cent of the author's patients developed atelectasis usually with

duodenal stump, and across to the left to the site of the anastomosis was always introduced. A fistul
for 24–
Institute

Beattie, A. D. (1949) *J. int. Coll. Surg.*, 12, 464.
Crile, G., Jun., Jones, T. E., and Davis, J. B. (1949) *Ann. Surg.*, 130, 31.
Grimson, K. S., Lyons, C. K., and Reeves, R. J (1950). *J. Amer. med. Ass.*, 143, 873.
Holloway, J. B., Jun., Armour, T., Jun., and Proctor, W. H., Jun. (1950). *Arch. Surg., Chicago*, 61, 487.
Hosford, J. (1949). *Brit. med J.*, 1, 929.
Kirsner, J. B., Humphreys, Eleanor M., Dragstedt, L. R., and Palmer, W. L. (1949).

l, 679.
Ann. Surg., 28, 417.
s. J., 61, 280.
oc. Mayo Clin., 24, 501.

PHARYNGEAL DIVERTICULA

See also B.S.P., Vol. 7, p. 1, S. Key 265.

Aetiology

NEGUS (1950) discusses the aetiology, evolution and treatment
nitial raising of the
altic wave executed
les are arranged in
associated with the
of the oesophagus
ali from the upper
al respiration. The
crico-pharyngeus
ngeal wall. During

flammatory lesions of the cric...
without any obvious pathological cause, and lack of relaxation due to deficient sensory

are given.

Negus, V. E. (1950). *Brit. J. Surg.*, 38, 129.

PHYSIOTHERAPY

See also B S P., Vol. 7, p. 9, S. Key 266.

...graphy in orthopaedics.
... tested fairly adequately

electromyographic equipment is expensive and until recently has not been commercially available, it has been largely used in research laboratories and abundant literature on the subject has accumulated. One of the most recently devised techniques relates to the transmission of nerve impulses to muscle, and opens up a large avenue of research, which should aid the further elucidation of still unsolved problems of neuromuscular dysfunction.

Watkins, A. L. (1949). *J. Bone Jt Surg*, 31A, 822.

POLYCYSTIC DISEASE

See also B S.P., Vol. 7, p. 103, S. Key 275.

inserted into the urethra, the prostatic lobes stripped from below upwards, and delivered separately. The gland is removed by cutting through the base. Tags and adenomas are removed from the bed, a wedge removed from the vesical neck ridge, and bleeding points ligated. A straight catheter is introduced into the bladder, the bed packed with Gelfoam [illegible]

died, one of post-operative bleeding, one of heart failure, and one of terminal broncho-pneumonia. On the whole, results were good and patients stood the operation well. Complications encountered were haemorrhage, temporary urinary fistula, sero-purulent discharge, pyuria, temporary urinary frequency, and epididymitis. The authors intend dusting the space of Retzius with sulphonamide powder in future.

Care and treatment of cases submitted to prostatectomy: use of sump drainage of bladder.— McCREA *(1949) describes at length the care and treatment of a patient submitted to supra-*pubic prostatectomy, and pleads for the more widespread use of post-operative sump drainage of the bladder in all such cases. The author strongly advocates stringent pre-operative care and advises prolonged drainage by supra-pubic tube or indwelling catheter and the maintenance of high urinary output until increased blood nitrogen retention is eliminated and excretory function restored to normal or as near normal as possible as [illegible] and the glucose [illegible] 80 milligrams of [illegible] the anaesthetic [illegible]

[illegible] cavity packed with gauze, which is removed in stages 24–48 hours after operation. A sump tube of the author's own design, connected to a suction pump, is then inserted into the [illegible] when the pack [illegible] removed when [illegible] at the period of [illegible] n addition, the [illegible] post-operative [illegible] ccur but rarely.

McCrea, L. E. (1949). *Amer J. Surg.*, 77, 411.
Presman, D., and Rolnick, H. C. (1949) *J. Urol*, 61, 59.
Smith, G. G. (1950). *J. Urol*, 64, 671.
Staehler, W. (1949). *Dtsch. med. Wschr.*, 74, 1155.
Twinem, F. P., and Davalos, A. (1949). *J. Urol.*, 61, 575.

PULMONARY TUBERCULOSIS

See also B.S.P., Vol. 7, p. 197, S. Key 281.

Treatment

[illegible] the surgical treatment [illegible] lysis of [illegible] divided [illegible] eration [illegible] inated. [illegible] of the [illegible] weeks [illegible] entially [illegible] authors [illegible] performed in [illegible] mplications [illegible] in Phrenic [illegible]

that the pulmonary reserve in these patients may be inadequate for normal living, even though the tuberculosis is eradicated; they therefore emphasize the need for caution in removing large amounts of lung tissue. Among 600 reported cases of resection without the use of streptomycin, there has been a 25 per cent operative mortality rate, with 12 per cent of empyema and 8 per cent of complicating broncho-pleural fistula. Among 129 cases reported by the Veterans' Administration in the United States, in which streptomycin was used, the mortality rate was 4·5 per cent; other authors have also reported comparable reductions in operative mortality.

Pneumoperitoneum treatment: indications and technique.—Some points in pneumoperitoneum treatment are discussed by THORKILDSEN (1949) with reference to his studies of the American literature and to his own experience in 5 cases of pulmonary tuberculosis. He found it necessary to refill the peritoneal cavity weekly. When cavities with rigid walls are

useless. Although in 1 advanced case of long-standing bilateral pulmonary tuberculosis the patient was greatly benefited, the author considers that the indications for pneumo-

dyspnoea being diminished, but in 2 cases it was later necessary to discontinue the pneumoperitoneum.

sputum conversion was obtained in 40 cases. Cavity closure in the upper zone is com-

Beattie, E. J., Jun., and Blades, B. (1949) *J. Amer. med. Ass.*, 139, 902.
Evans, E. W. T. (1950) *Brit. J. Tuberc.*, 44, 67.
Thorkildsen, R. (1949). *Nord Med.*, 41, 151.

RADIOTHERAPY

See also B S P., Vol. 7, p. 268, S. Key 286.

1949) discusses the whole field of
though he agrees that operative

disease may occur from involvement of skin, lymphatic system, haemopoietic tissues, bones

replaced by such tissue. Among the laboratory investigations which *may be employed in the*
of sarcoid
heat and
tive if an
indolent papule or ulcer forms at the site of the injection and persists for months. Raven

generalized tuberculosis supervenes.

Raven, R. W. (1949). *Ann. R. Coll Surg.*, 5, 3.

RECONSTRUCTION OF THE EAR AND NOSE

See also B.S P., Vol 7, p 306, S. Key 288.

Reconstruction of the nose

The role of the septum.—The rationale of rhinoplastic reconstruction is discussed by

resection. Septal deformities are thus classified: (1) septal deflection with over-sized hump deformity, (2) crushed septal fracture with depressed external deformity, and (3) septal deflection with external lateral deviation. In class I deformities it is necessary to preserve

by vertical excisions of narrow segments along its entire height, or by
curvatures are only slight. This procedure is effected without separating the muco-peri-
which serves as a splint for the re-shaped septal cartilage. A
bilization of the septum, thus dis-

Malniac, J. W. (1948). *Arch. Otolaryng., Chicago*, 48, 189.

RECTUM—CARCINOMA OF

See also B S.P., Vol 7, p. 325, S. Key 290.

Pathology

Mode of extension of carcinoma of the rectum.—BACON and SAUER (1950) review present

to the middle Houston valve. This area drains along collecting trunks accompanying the middle haemorrhoidal vessels, in particular to a gland described by Quénu. Spread to the middle and lateral sacral glands sometimes occurs, but spread through the levatores ani, as postulated by Miles, is rare. (2) The superior lymphatic area is less accurately delimited, but it drains into the glands accompanying the superior haemorrhoidal vessels described by Gerota Spread of the growth along this chain is usually in an orderly and predictable manner. An invaded gland delays further spread until it is almost completely destroyed itself.
has a l
origin
"skipp
spread that evidence is most lacking. Most authors agree, however, that downward or

Operative treatment

Vesical dysfunction following abdomino-perineal recto-sigmoidectomy.—EWELL (1950)

investigations are necessary are of the male sex, the author queries why this should be. He points out that in males of this group urinary obstruction may be impending and that in the female interposition of a uterus and broad ligaments may reduce operative trauma to

are discussed. The neurogenic theory of autonomic nerve injury is most supported but many investigators fail to confirm the cystometric evidence and some cure their cases by

Simplified abdominal
the view
growth is
ing perin
fascia pr
abdominal proctosigmoidectomy with colostomy and peritoneal drainage through the anal

sphincter. The left and right peritoneal leaflets of the rectum and sigmoid are divided respectively wide of the bowel and medial to the right ureter. The mesentery is divided from its peritoneal margin to the bowel which, after the application of clamps, is divided by cautery or scalpel. Provision for drainage is made by the introduction through the lower [illegible] rectum and the denuded pelvic surfaces. The mesentery is then drawn down anteriorly to cover the intestines, the sigmoid, forming the colostomy, protruding from the abdominal incision. Perineal gauze pads may be used to offset any tendency to ascending peritoneal infection. The anal gauze remains undisturbed during the first 4 post-operative days, after which it is partly withdrawn, with complete removal by the seventh day. Convalescence is shorter and more comfortable than with the established techniques, and the operation allows for subsequent abolition of the colostomy by anastomosis. It can be performed for the radical cure of malignancy [illegible] *for adequate extirpation by* [illegible] diverticulitis and traumatic [illegible] the inexperienced operator.

Babcock, W. W. (1950). *J. int. Coll. Surg.*, 13, 515.
Bacon, H. E., and Sauer, I. (1950). *J. int. Coll. Surg.*, 13, 24.
Ewell, G. H. (1950). *J. int. Coll. Surg.*, 14, 39.

SACRO-COCCYGEAL REGION—SURGERY OF

See also B.S.P., Vol 7, p. 417, S. Key 297.

Tumours

[illegible] associated [illegible] squamous [illegible] ollicles are [illegible] exion with [illegible] chio-rectal [illegible] us, syphilis [illegible] forms of [illegible] and x-ray therapy. These surgical approach [illegible] (1) incision and drainage under [illegible] with the use of local Novocain [illegible] necessitate a short or long period of in-patient hospital treatment, the main ones being, [illegible] *method as the one giving the best end-results.*

Berkowitz, J. (1949) *Amer. J. Surg.*, 77, 477.

SALIVARY GLANDS

See also B.S.P., Vol. 7, p. 430, S. Key 298.

Physiology

Functions of the parotid gland.—Nash and Morrison (1949) discuss the functions of the parotid gland. The gland is a compound tubular or albuminous gland consisting of clusters

... with a relatively meagre interacinar stroma of

[illegible]

blood; in addition, it contains amylase, [illegible] and experimental evidence during the past 75 years has shown some inherent relationship ... (primarily the parotid) and the glands of internal secretion ... blood ... cula- ... doubt ... thods ... g the testicles, ovaries, pancreas, breast and central nervous system, are well known. Because of the similarity between the parotid gland and the pancreas and of the apparent parotid hypertrophy in cases of diabetes, research has been done on the alteration in the blood-sugar levels in parotidectomized rats, in an attempt to locate a carbohydrate-regulating hormone, similar to that of the pancreas. Ligature of the duct has also been performed in ... to influence the blood sugar level. The opinions of the

[illegible]

Tumours

Results of radiation therapy in parotid tumours.—Radiation therapy, in the opinion of Smith and Stenstrom (1949), may be necessary for the treatment of parotid tumours, ...

[illegible]

... The nodules are usually painless but sometimes tender

[illegible]

patient appeared for diagnosis, even as long as 30 years.

Wounds

Repair of lacerated parotid duct.—Bailey and Skaff (1949) report on 5 cases of the successful repair of a lacerated parotid duct. A review of previously reported cases of duct ...

[illegible]

about 1 5 centimetres in length, is made, and a probe is passed through the mouth into the

[illegible]

the cotton strand is threaded through a long Mayo needle, which is passed backwards, blunt end first, into the proximal duct, and is manipulated through the parotid gland to a small skin incision. The thread is carried through, and a lead shot is attached to each end, a small piece of rubber sheeting being placed between the mucosa and the lead pellet to

or silk dowel being left *in situ* until the fourteenth post-operative day. Salivary flow into the mouth usually returns soon after operation. In the authors' 5 cases, laceration of the duct had been present in some instances for a few days and in others for some weeks.

Bailey, H. A., and Skaff, V. (1949) *Ann. Surg.*, 129, 103.
Nash, E., and Morrison, L. (1949). *Ann. Otol., etc., St. Louis*, 58, 976.
Smith, M. J., and Stenstrom, K. W. (1949). *Radiology*, 52, 655.

SPINAL COLUMN

See also B S.P., Vol. 7, p. 539, S. Key 306.

Tuberculosis

Diagnosis and treatment of Pott's disease (spinal caries).—GIRDLESTONE (1949) describes spinal caries as the most common and the most dangerous form of skeletal tuberculosis. Delay, or a mistake in the diagnosis of an aching back, may lead to treatment for a supposed lumbago or a lesion of an intervertebral disc. If, owing to some mistaken diagnosis, the patient is given an anaesthetic, then the relaxation of protective muscular control of the

... infected bone of the
Other dangers
deformity and
h aseptic dress-
cent in 75 per
... abscess. Pro-

... will give ...
fter operation is
complete control
as upon antero-
-ssion, operation
ie relatively safe
. Laminectomy,
here is no relief.
paraplegia with
evious posterior
spinal graft.

... A review is made by BOSWORTH and
surgically at Sea View
5 tuberculous patients
laimed that decreased
the authors' operated
ths occur in the sixth
decade. ... 5½ months, compared
with 26½ ... , females 66. Negroes
showed ... white patients. With
regard to ... r thoracic or lumbar
... firming Girdlestone's
regions.

changing the picture There is a surprising lack of correlation between mortality and open tuberculosis; 24 3 per cent of patients had positive sputum or stomach washings; the mortality figure of 34 9 per cent was only 2 8 per cent over that of the whole series. These improved figures are possibly due to better control of pulmonary tuberculosis Cleveland believed the prognosis in such cases to be exceeded unfavourably by those with metastatic spread. Extraspinal bony foci carried a 91·7 per cent mortality if the lesions were multiple; 66 7 per cent of patients with other non-bony non-pulmonary lesions died.

Injuries of the spine

Fracture of spinous processes by muscular action: operative treatment—The fracture of one or more spinous processes of vertebrae in the cervico-thoracic region by muscular action is reviewed by SICARD and CARRAGE (1948) This fracture, known in Britain as clay-shoveller's fracture, is most commonly seen in workmen who have, with outstretched arms,

shovel, tears off the spinous process There is sudden intense pain, worse on attempting to move the neck or shoulders, and examination reveals a tender point over the fracture In

Treatments recommended by various authors range from masterly inactivity to immobilization in plaster and removal of the broken piece of spinous process. This small operation is warmly advocated by the authors, who have carried it out in 3 cases with success.

Non-traumatic atlanto-axial dislocation causing quadriplegia—A case of non-traumatic

severe, and on the fifth day an almost complete quadriplegia was present. Radiography showed a post-pharyngeal soft-tissue swelling, as seen in an earlier skiagram, but it also revealed an anterior displacement of the first cervical vertebra on the second, with destruction

first, second, third and fourth cervical vertebrae being performed, together with decom-

pain, thought to be caused by injury to the cranial nerves, was present for some time. On examination about 13 months after the incidence of the pharyngeal abscess, the patient was found to have recovered completely.

Bosworth, D. M., and Levine, J. (1949). *J. Bone Jt Surg.*, 31A, 267.
Girdlestone, G. R. (1949). *Ann. R. Coll. Surg. Engl.*, 4, 214.
Sicard, A., and Carrage, P. (1948). *Pr. méd.*, 56, 887.
Titrud, L. A., McKinlay, C. A., Camp, W. E., and Hannah, H. B. (1949). *J. Neurosurg.*, 6, 174.

SPINAL CORD

See also B.S.P., Vol. 7, p. 573, S. Key 307.

Tumours

Diagnosis and treatment of intraspinal tumours.—Adson (1950) urges the earlier diagnosis of intraspinal tumours, because most of them are benign and are amenable to surgical treatment. Those originating outside the cord outnumber those within, in a ratio of 4 : 1, *excluding protrusions from intervertebral discs. Most intraspinal tumours occur in the* [illegible]

[illegible] the narrow intervertebral foramen This shape necessitates 2 incisions or, in the thoracic region, a 2-stage operation. The meningioma must be removed intact with the arachnoid and dura related; otherwise recurrence is inevitable. Of the intramedullary tumours, the largest group are the ependymomas, which also can be removed complete. The author [illegible]

Neurofibroma: benign, intraspinal-intrathoracic "hour-glass" tumour with paraplegia— [illegible] "hour-glass" tumour with [illegible] amount of sputum. [illegible] *after radiography* at a travelling [illegible] een advised to consult a physician; but he failed to do so until shortly before admission to hospital, about 4 months later. [illegible] below the sixth thoracic [illegible] cles [illegible] *left* [illegible]

[illegible] produce tumour tissue. Intensive [illegible] and the paraplegia became more [illegible] extradural tumour was found, [illegible]

no evidence of malignancy. The authors emphasize the danger of subjecting any tumour causing spinal-cord compression to radiotherapy without preliminary biopsy.

Operations for other causes of compression paraplegia

part of the back, radiating to the lower abdomen on both sides. She had had a shivering attack and had vomited Her own doctor had found signs of consolidation, so she was given sulphonamides and spent 5 weeks in bed; she continued to lose weight and her periods ceased. A month before admission she began to have pains in the right iliac crest and groin and the left hip; a week before admission to hospital her legs became weak and there was loss of rectal and urethral sensation. Examination on admission showed hypotonia and wasting of the lower limbs with bilateral foot-drop Radiography revealed widening of the interpedicular space of the twelfth thoracic vertebrae and slight widening of the interpedicular space of the first lumbar vertebra. Myelography by the cisternal route showed the contrast material held up completely at the lower border of Th.12 Examination of the cisternal cerebr

of protein per

dura was foun

was obliterated

mottled. A "tumour", 2 inches long, extended downwards from the conus and slightly to the right Aspiration of the conus and of the swelling yielded purulent material from which

recover from a space-occupying lesion within its substance is far greater than is generally supposed The author emphasizes the desirability of early recognition of this condition.

Other operations on the cord

enter by the spinal nerve

separate from the motor

the pain pathway in the

and the development of drug addiction.

Chordotomy, sympathectomy and

Relief of pain was most pronounced in cases of abdominal and pelvic malignancy, phantom limb and disease of the spinal roots. Spinothalamic tractotomy at higher levels was accompanied by an increased mortality rate. Ganglionectomy was the favoured procedure for angina pectoris. Although pain of visceral origin, such as aortic aneurysm and dysmenorrhoea, responded well to the safe and harmless operation of sympathectomy, the author gives warning that relief by this operation is confined to pain originating in the heart and aorta, or in abdominal viscera unaffected by malignancy. In view of the psychical deterioration which occurs after
of prefrontal leucotomy should
tomy can effect a cure with fewer

Adson, A. W. (1950). *J. int. Coll. Surg.*, **14**, 1.
Alexander, E., Jun., and Janes, R. M. (1949). *Ann. Surg.*, **129**, 267.
Foley, J. (1949). *Lancet*, **2**, 193.
Siris, J. H. (1949). *N.Y. St. J. Med.*, **49**, 1681.
White, J. C. (1950). *Lancet*, **2**, 161.

STERILIZATION OF SURGICAL APPARATUS

See also B.S.P., Vol. 8, p. 39, S. Key 311.

Methods

Sterilization of operating room by means of antibiotics.—The first operating room to be sterilized by means of antibiotics is described by DOGLIOTTI (1950). Experiments with exposures of agar-agar plates during the course of surgical procedures showed growths of air-borne pathogens in the operating rooms in which the common methods of asepsis were

by those engaged in the room is not considered disadvantageous. The constant change of pathogenic organisms is inimical to the development by them of antibiotic resistance, and any such germs would be destroyed by the nocturnal ultra-violet radiation. The guarantee of absolute asepsis, for the reasonable cost of 2,000,000 oxygen units for 3–4 hours, is a justifiable expense.

Dogliotti, A. M. (1950). *J. int. Coll. Surg.*, **13**, 640.

STOMACH—DISEASES OF

See also B.S.P., Vol. 8, p. 49, S. Key 312.

Surgical treatment

CHAMBERLAIN (1949) enumerates his views
on for any surgical operation is
perative treatment, and should

favour palliative resections in the presence of irremovable secondary deposits, but he urges gastrectomy in every operable case. Certain cases will be operable only by a thoracic approach, but there is insufficient evidence yet to determine whether or not the more recent radical total gastrectomy is justifiable. In gastric ulceration medical treatment is satisfactory, provided that definite evidence of healing is obtained, and for this purpose gastroscopy is more reliable than radiography. But ulcers which continually recur, which are adherent to the pancreas, which cause recurring haemorrhages or, by refusing to heal, become suspect of carcinomatous changes—all these require gastrectomy. Hour-glass deformities also are best dealt with in this way. It is, however, for duodenal ulceration that gastrectomy is most

jejunal ulcer, and (3) a gastro-jejunal ulcer, whether the last-mentioned is simple or is complicated by a gastro-colic fistula. Rarely simple tumours, if extensive, may require

supervene He reserves vagotomy particularly for the younger patient with duodenal ulceration, high acidity and no stenosis.

Sarcoma

Gastro-intestinal lymphosarcoma.—Gastro-intestinal lymphosarcoma is stated by SPELLBERG and ZIVIN (1949) to be a rare disease, which occurs either as a primary growth with subsequent lymph-gland involvement or as part of a generalized lymphosarcoma The authors describe 21 cases of primary gastro-intestinal growths. In the 11 cases in which the primary growth was in the stomach, the patients' ages ranged from 26 to 57 years The

the treatment of choice

Chamberlain, D (1949) *Med Pr*, 222, 265.
Spellberg, M. A, and Zivin, S (1949) *Arch intern Med.*, 83, 135

SUBPHRENIC ABSCESS

See also B.S P, Vol. 8, p. 104, S. Key 314.

and two extraperitoneal subphrenic spaces, and, opposing the view of any writers, defines

clinical appearances produced by infection in the suprahepatic and infrahepatic spaces, the author finds that in this series abdominal and chest symptoms occurred together in most cases, but that when they were confined to the chest the infection was always suprahepatic.

Left-sided abscess presented some important features; elevation of the diaphragm was less frequent, as compared with right-sided infection, and malignant disease was a more frequent causative factor. Multiple space infect[illegible] al than were single-space [illegible] 9·3 per cent of the series, [illegible] The author finds that the great majority of subphrenic abscesses are due to abdominal infections close to the resulting abscess. With regard to the spread of infection, he found no evidence to support any theory of lymphatic spread, but he describes animal experiments to show that the variation in intra-abdominal pressures is probably sufficient to lead to upward spread with the patient in any position. Intrathoracic suppuration, occurring in about 25 per cent of cases, was found to be due most often to perforation of the diaphragm or to transpleural drainage of the abscess. Again, no evidence was found to incriminate the lymphatic vessels. The presence of a bronchial fistula with intrathoracic [illegible] and gas below a cupola. On the question of treatment, the author strongly advocates extra-serous drainage and condemns the trans-serous route. He also advises against diagnostic aspiration.

Incidence and treatment of subphrenic abscess.—In the opinion of SHEA and HOLDEN (1948), the mortality rate of subphrenic abscess remains higher than it should be. These authors believe that a discussion of the factors contributing to a high mortality rate may be of benefit. They include in their report 40 cases seen during the past 12 years at the University Hospitals of Cleveland. In their series, the right posterior superior space was infected in 18 cases. The subphrenic spaces may become infected: (1) by direct intraperitoneal extension, (2) by rupture of adjacent abscesses, (3) by lymphatic extension, (4) direct implantation fo[illegible] local pain and tenderness, and an elevated fixed diaphragm. The surgical approach of choice is retroperitoneal. This operation was performed in 20 out of the 40 cases; in 8 cases transpleural drainage was used, and in 2 cases aspiration; in the remaining 10 no operation was performed, either because the diagnosis was not made or because permission to operate was refused. The authors mention transpleural or transperitoneal aspiration only to condemn it. Penicillin was given in 9 cases in doses of 15,000–20,000 units every 3 or 4 hours. In 6 of these cases sulphadiazine was also given, either orally or intravenously. Retroperitoneal drainage was performed in 6 of these 9 cases, and all these patients survived. [illegible]

Harley, H. R. S. (1949) *Thorax Lond.*, 7, 1.
Shea, P. C., Jun , and Holden, W D. (1948). *Arch. Surg., Chicago*, 57, 843.

SURGICAL TECHNIQUE

See also B S.P., Vol 8, p. 124, S. Key 316.

Operative management

Control of the circulation with hypotensive drugs and by posture.—The control of circulation [illegible] and changes in posture, to reduce bleeding in surgery, [illegible] subje[illegible] obta[illegible] half [illegible]

Tetraethylammonium chloride and hexamethonium iodide produced similar, but slightly less marked, effects. It has been *found that the position of the patient and the effect of* gravity are factors of major importance, both in sympathetic block and in the use of ... ; a foot-down

... be relieved by

... The capillary

... period; if it is

prolonged, Methedrine (deoxy-ephedrine) should be available but should not be used

... 50 cases, but

in 9 cases

... NARAT,

eport on

oclaving

n that of

hen wet,

During

, (3) silk

suture material in a series of 16 major operations, in these cases daily inspection of the

approximated, and not crushed, when tied off. Although the authors are not convinced of the necessity of avoiding continuous sutures with non-absorbable material, they recommend the preservation of the principle until further experience is gained in this direction.

Enderby, G. E. H. (1950) *Lancet*, 1, 1145.
Narat, J. K , Cipolla, A. F., and Cangelosi, J. P. (1950). *Arch. Surg , Chicago*, 60, 1218.

TESTICLE AND TUNICA VAGINALIS

See also B S P., Vol 8, p. 174, S. Key 320.

Imperfect descent of the testes

Timing of surgical treatment of undescended testicle —Management of the patient with undescended testicle is discussed by DOUGLAS (1949). Since 1938 he has treated 52 patients with a total of 63 undescended testicles. Only 20 patients were under 14 years of age, and 32 were over 14 and past puberty. Of the 52 patients, 15 treated by orchidectomy or abdominal replacement were not followed up; 27 of the remainder were traced. In 7 children and 4 adults the abnormality was bilateral, showing that in not all bilateral cases do the testicles descend at puberty, but suggesting that in some of the 7 children the testes might have descended spontaneously if left alone. There were 6 ectopic testes in

performing orchidopexy. All orchidopexies should be by the Keetley-Torek or Turner method, in which there is prolonged fixation in the new position. Cases of unmanageable associated hernia may require earlier operation. No attempt should be made, in children under 6 years of age, to bring the testicle into the scrotum. Hormonal treatment is recorded as being given in 8 cases, but in none did there appear to be any response to the therapy.

Hydrocele

Injection treatment.—WILSON (1949) writes on the advantages of treatment for hydrocele by injection rather than by operation. He quotes other authors [illegible] superior results are obtaine [illegible] scrotal oedema, formation [illegible] is also claimed In all, 18 p[illegible] spermatocele. Follow-up e[illegible] excellent results. The author submits that treatment by injection avoids operation and in-pat[illegible] In onl[illegible] cure. [illegible] area o[illegible] iodine [illegible] the testis lies posteriorly. Through a wheal of 2 per cent procaine, a large aspirating needle is inserted into the tunica vaginalis, carefully avoiding visible blood vessels. As much hydrocele fluid as possible is evacuated, in order to prevent dilution of the sclerosant, and the testis and epididymis are then carefully palpated to exclude an underlying lesion Quinine with urethane (6 millilitres) is injected and massaged around the sac. The needle is then withdrawn and the puncture sealed with a wisp of cotton-wool. Transient pain occurs [illegible] provided that no technical error is made.

New growths of the testis and epididymis

Pathological study of testicular tumours.—WYNDHAM (1949) describes a detailed study of 41 personal cases of testicular tumours, most of which have been under observation for 4 or more years; 5 tumours occurred in maldescended testicles. The author's aim is to suggest how much information one can deduce from pathological study, but he avoids pathological controversy. He recognizes (1) the seminoma, (2) the anaplastic, unicellular tumour and (3) the teratoma. (1) There were 17 seminomas with typical uniform microscopical appearances—cells resembling spermatocytes or Sertoli cells—and a frequent suggestion of tubular origin. Most of the patients were between 30 and 40 years old, but prognosis was unaltered by age. All were radiosensitive and all have done well. The 5 cases with metastases are described in detail. Lymphatic spread was typical. Investigation of urinary hormones was of no diagnostic aid. (2) There were 5 cases of anaplastic unicellular tumour, often incorporated with seminomas as embryonal carcinomas. The author's experience is that these occur in younger patients, are highly malignant and are radio- [illegible] The tumours are vascular, have no composite structure and the cells do not surround spaces. (3) There were 19 teratomas, and these the author subdivides into (*a*) 12 cases clearly showing derivatives of more than one germ layer, and (*b*) 7 cases which he terms haemorrhagic adenocarcinomas. As a group all the patients were younger than those with seminomas, all were of poor prognosis and all were radio-resistant. There was no correlation between either the concentration of urinary hormones, or structure, and prognosis. It is often impossible even to be sure that more than one germ-layer is or is not represented. [illegible] looked but were in fact particularly malignant; [illegible] ieves this [illegible] tumour [illegible] seminoma [illegible] different [illegible] not semi- [illegible] stis may [illegible]

Douglas, A (1949). *N Z med J*, 48, 4.
Wilson, W. W. (1949) *Lancet*, 1, 1048.
Wyndham, N. R. (1949) *J. int Coll. Surg.*, 12, 431

THROMBOSIS AND EMBOLISM

See also B S P., Vol. 8, p. 234, S Key 324.

Prophylaxis

frequent determinations of prothrombin time were made, and these showed an appreciable prolongation, lasting from 2 to 5 days. Subsequently a single test was made to exclude any hypersensitive patient, but recently all routine investigations have been omitted as unnecessary The administration of the drug has been altered recently. At first, patients of

dicoumarol every 4 or 5 days after the second dose, for as long as the patient remains in hospital.

Smith, G. V. S (1950) *Surg Gynec Obstet.*, 90, 439.

THYMUS GLAND

See also B S P., Vol 8, p 243, S Key 325.

Thymectomy

thymic tumour amongst patients with myasthenia gravis is much less than is often supposed, and probably not significantly greater than the incidence of 15 5 per cent detected by radiographic examination in their own small series. Regarding the selection of patients for surgical treatment, contra-indications comprise: (1) definite clinical and radiographic evidence that the tumour has implanted itself widely, and (2) clinical evidence that the

sufficient certainty to exclude spontaneous remissions In certain cases the thymic tumour is present before the onset of symptoms of myasthenia gravis. It may be that x-ray irradiation of the thymus gland would be of value in treatment. It is advocated that, before a conclusive

opinion can be given of the value of thymectomy in myasthenia gravis, a group treated surgically should be compared with a group of patients receiving medical treatment only.

Eaton, L. M., Clagett, O. T., Good, C. A., and McDonald, J. R. (1949). *Arch. Neurol. Psychiat., Chicago*, 35, 5.

THYROID GLAND—DISEASES OF

See also B S.P., Vol. 8, p. 256, S. Key 327.

Pre-operative preparation

Medical treatment of thyrotoxicosis prior to operation.—In the years 1940–48, GENEWEIN and WEBER (1949) treated 77 cases of severe or very severe thyrotoxicosis in a Bavarian [illegible]

the patient fit for operation. Each patient was put on a regimen of absolute physical and psychical rest, and was given a diet poor in animal protein and rich in carbohydrate and vitamins A, B and C. During the 8 years' period, preparations containing quinine, ergot and phenobarbitone have been administered, but for the past 3 years the authors have [illegible]

Anaesthesia

Problems of anaesthesia in thyroid surgery—ROWBOTHAM (1949) discusses the problem of anaesthesia for thyroid surgery. The several types of goitre each present special problems. In the obstructive type there may be pressure on the trachea, pharynx or oesophagus, or on the recurrent laryngeal nerve. Intrathoracic goitre causes pressure on the [illegible] Malignant disease [illegible]

[illegible] ous and [illegible] chloride [illegible] botham [illegible] nd con- [illegible] ized, and blind [illegible] is taken to see [illegible]

[illegible] ed the value of [illegible] cation, and the [illegible] of the operative [illegible] 0 patients with- [illegible]

Genewein, A., and Weber, M. (1949) *Med. Klin.*, 44, 948.
Hewer, C. L. (1949). *Proc. R. Soc. Med.*, 42, 118.
Rowbotham, S (1949). *Proc. R. Soc. Med.*, 42, 115.

TUBERCULOSIS

See also B S P., Vol. 8, p. 311, S. Key 330.

Diagnosis

be carried out

The Mantoux tuberculin test in diagnosis · negative reactions —STILWELL (1950) believes that the reduction in mortality and morbidity from tuberculosis in recent years has increased the number of adults who give a negative reaction to the Mantoux tuberculin test. Thus the

milligram intracutaneously, has been employed for patients 16 years of age or older. This dose is safe unless there are grounds for suspecting active tuberculosis, when weaker

"single strength" dose react positively to the "second strength" dose, as used for children, but many of these reactions are believed to be non-specific false positives. False negative

Chemotherapy

Streptomycin treatment in genito-peritoneal tuberculosis —SERED, FALLS and ZUMMO (1950) report on 16 cases of genito-peritoneal tuberculosis in females, treated with streptomycin, in which the diagnosis was made before operation They were given the drug

culosis of the cervix in 3 cases; abscess of the breast, a tuberculoma of the brain and a

procedure, favoured in this investigation, was a minimum course of 6 weeks before operation, followed by 3 weeks of the antibiotic treatment post-operatively. All patients showed

improvement in every respect, weakness and fatigue diminishing, appetite improving, and abdominal distension and "doughiness" being much alleviated. Only 1 patient died—a Negress who w

authors advise

This antibiotic

tuberculosis of the female genital tract.

Sered, H., Falls, F. H., and Zummo, B. P. (1950). *J. Amer. med. Ass.*, **142**, 547.
Stilwell, G. G. (1950) *Proc. Mayo Clin.*, **25**, 422.
Weed, L A. (1950). *Proc. Mayo Clin.*, **25**, 430.

ULCERS AND ULCERATION

See also B.S P , Vol. *8*, p. *339*, S. Key *332*.

Rodent ulcer

pilosebaceous ducts. The amount of stroma varies but is usually relatively large. It may be fibrous in chronic types and embryonic in the more malignant tumours. In 14 of the authors'

floor showing clean granulations, sloughs or crust formation. Secondary infection may result in necrosis, with inflammation of the surrounding skin. Typically there is no deep

tenebrant types

7 and Johnson in

ittle in 1923 as

"erythematoid benign epitheliomata". Involvement of trunk and limbs by basal-cell

The authors recommend surgical excision of all rodent ulcers.

Wakeley, C., and Childs, P. (1949). *Brit. med J.*, **1**, 737.

URAEMIA

See also B.S.P., Vol. 8, p. 361, S Key 334.

Treatment

Management of anuria.—MILLER (1949) discusses the management of the patient with

effect on secretion, and decapsulation of the kidney, used in 3 cases, was also ineffective.

subsides.

catheter placed in the upper abdomen under local anaesthetic The outlet was a Chaffin

cc
se
ch
pa
ni
retention has not been sufficiently stressed. The immediate cause of death in their fatal cases was acute pulmonary oedema They remind us that pulmonary oedema tends to occur

long continuous lavage, considerable amounts of fluid are absorbed from the peritoneum since no substance can be added with an osmotic effect comparable to that of plasma proteins. Thus overloading of the circulation is a constant risk. They believe that daily chemical estimations must be performed and the irrigating fluid altered accordingly; but they show that typical electrocardiographic changes can indicate fall and rise of various electrolytes. Expert supervision is therefore required and peritoneal contamination after 4 days seems inevitable. They advise, however, that peritoneal lavage is indicated when the electrolyte pattern is disturbed, especially in hyperpotassiumaemia or when toxic symptoms occur with severe azotaemia.

Peritoneal irrigation in an infant with

white cells and culture yielded colon bacilli and nonhaemolytic streptococci There was 100 6° F. temperature, hypochromic anaemia and a 24,400 leucocytosis. mainly poly-

daily chemical findings are enumerated in the paper.

The artificial kidney.—The use of the artificial kidney is described by MURRAY, DELORME

was carefully mixed and autoclaved to prevent precipitation of insoluble salts

by filling the machine with blood suitable

Buerger, W R., Lambert, E. C., and Maitland, Barbara A (1949). *Amer. J. Dis. Child.*, 13, 237.
Fields, I. A., Martin, H. E., Simonsen, D. G , Wertman, M., and Westover, L. (1949). *Ann. Surg.*, 28, 445
Miller, A. (1949). *Proc. R. Soc. Med.*, 72, 801.
Murray, G., Delorme, E., and Thomas, N. (1949). *Brit. med. J.*, 2, 887.

URETER—TRANSPLANTATION OF

See also B.S.P., Vol. 8, p. 370, S. Key 335.

Pre-operative preparation

Pre-operative regimen and operative technique.—FLOCKS (1949) describes a regimen for

the author has been able to operate in

agement is
Whenever
teinaemia,
Four days
on a low-
times daily, and also 4 daily

is left in situ

interval after the second stage of the anastomosis

Indications for uretero-colic anastomosis

Transplantation for bladder contracture following renal tuberculosis—JACOBS (1949) advocates transplantation of the ureters for the contracture of the bladder which follows renal tuberculosis The origin of the contracture is not clear, for the spread of tuberculosis is in the submucosa. The author thinks that the infiltration of the musculature may be a response to the diffusion of tuberculous toxins. There is a progressive diminution in the capacity of the viscus until, as he states, the bladder is finally of thimble-like dimensions

neither nephrostomy nor ureterostomy is a satisfactory operation. Whenever possible,

intervention is successful and there is good rectal control, the urine can be retained for from 4 to 6 hours. Some of the long-term results are very good, 1 patient, for example, being healthy and in full employment 6 years after transplantation of the right ureter; the left kidney had been removed 10 years previously. The author agrees that such a result is exceptional, but he considers that the hope of even temporary relief from the distressing symptoms of contracture justifies operation in many cases

Operative technique

Modification of the Coffey uretero-enterostomy.—THOMSON (1949) describes a new

passes a sigmoidoscope up to this level. A piece of 18-gauge copper wire, 20 inches long and bent like a hairpin, is then pushed into the bowel so as to fix the ureter firmly but not obstruct it. The assistant then twists the limbs of the "hairpin" *via* the sigmoidoscope until they are entwined up to the bowel wall. Finally a length of plastic tubing is pushed over the

represented a bad operational risk.

Technique and results of Cordonnier's uretero-sigmoid anastomosis.—CORDONNIER (1949) describes his own method of uretero-sigmoid anastomosis, and the results of the operation in 26 consecutive cases. The three fundamentals of the method are: (1) minimal disturbance

Wangensteen suction is employed, and fluids are given intravenously. The approach to the ureter is transperitoneal, and care is taken not to dissect out too much of the lower end of the ureter at the pelvic brim. An incision of not more than 2 centimetres is made in the

and peritoneum are then united around the incision and the parietal peritoneum is repaired.

reproductions of the intravenous pyelograms of the first 8 cases submitted to operation In employing this method it is not necessary to use a taenia coli as the site of implantation, and the author believes that it is better not to do so.

The muscle flaps were united by interrupted sutures, care being taken that the ureter ... the Stiles' method the incision was made directly ... ved as before and buried by interrupted sutures. ... ne or at a subsequent operation. Post-operative diuresis was promoted by ... stration was continued for ... bladder, there were 5 deat... peritoneal method is that it does not allow complete abdominal exploration.

Surg. Gynec. Obstet., 88, 441.
39, 626.

90

URETHRA AND BLADDER—CONGENITAL MALFORMATIONS

See also B.S.P., Vol. 8, p. 383, S. Key 336.

Hypospadias

Two-stage treatment—DODSON (1949) reviews the treatment of hypospadias. Incomplete

a transverse ventral incision in front of the hypospadic opening and freeing the opening from fibrous tissue; in severe cases a second incision may be made at the base of the glans. Haemostasis is effected and the skin and fascia are closed longitudinally. Should the skin constrict the penis, a short longitudinal incision may be made in the dorsum of the organ

best method of carrying the urethra forward to the end of the penis is that of Davis.

Dodson, A. I. (1949) *J. Urol.*, 61, 116.

URETHRA—NEW GROWTHS AND STRICTURE

See also B.S P., Vol. 8, p. 407, S Key 337.

New growths of the penis and urethra

Pathogenesis and treatment of penile carcinoma—The possible prophylaxis of penile carcinoma is suggested by BLEICH (1950), as the result of a study of its pathogenesis. The disease shows an incidence of between 2 and 5 per cent of all carcinomas in males in America and Great Britain, most of the cases occurring between the ages of 40 and 60 years. The incidence is higher among Negroes than in white persons, and is considerably higher in oriental races The disease is encountered relatively rarely among Jewish people and Mohammedans, in fact, only 2 cases in Jews have been recorded, one being in an uncircumcised Jew, in the only instance of its occurrence in a circumcised Jew, the man had been circumcised at the age of 8 days, but at the age of 16 years he had a syphilitic lesion of the penis, which was cauterized, and later narrowing of the external urethral meatus developed. Superficial tumours, no larger than 2 5 centimetres in diameter, may be treated radiologically; neither radium nor high-voltage x-ray therapy diminishes the erectile property of the penis, but sterility is almost inevitable Surgical treatment is usually the method of choice, including, in the case of large lesions, amputation of the penis and resection of inguinal lymphatic glands, inguinal adenopathy is estimated to be present in 80 per cent of cases, but actual metastases are present in only 50 per cent Toxic absorption from ulcerating primary tumours is responsible for the additional adenopathy. The sites of

Bleich, A. R (1950). *J Amer. med. Ass*, 143, 1054.

UTERUS—FIBROIDS

See also B.S P , Vol 8, p. 427, S. Key 339

Operative treatment

oophoritis or ot
enlarging the ute
perineum is relax... prolapse allows abnormal mobility It can be
... drawback from the operator's standpoint. Self-retaining retractors are never satisf
here. Every operative detail is enumerated, but they follow the procedure of Hea
illustrated ...
essential.
the vagina
space betw
and the combined uterosacral and cardinal ligaments are now exposed and transfixed,
which the uterine vessels are tied. The uterus is now attached only by the broad ligan
and to clamp these the fundus ...
of Douglas. The pelvis is then ...
each side of the vagina, which, ...
vaginal wound, which is itself cl...
run into the peritoneal cavity The peritoneum is not drained. Post-operative peni
50,000 units 3 hourly for 48 hours, is routine.

History of Wertheim's operation.—BONNEY (1949) reviews the history of Werth

abdominal or vaginal hyster
a 10–15 per cent operabilit
Wertheim's operative morta
gynaecologists, many of wh
the operation began to be p
Berkeley, performed his first
The operability rate was 63

rising to 80 per cent in cases seen in private practice. His criteria of operability have rema
unchanged over the years. His operative procedure differed from that of Wertheim in
the greater part of the vagina was removed, and the regional glands are also remo
whether obviously involved or not. Although there is a marked difference in the resul
cases where the glands are involved, cure is possible. A large number of Stage III c
are operable. Bonney has not used pre-operative or post-operative radiation in his ca
except for a few cases in which growth was irremovably fixed to the pelvis at operat
... surgery, s
... ne not enti

Atlee, H. B., Colwell, W. G., and Perlin, I. A. (1949). *Canad. med. Ass. J.*, 70, 44
Bonney, V. (1949). *Lancet*, 1, 637.

UTERUS—CARCINOMA OF THE BODY

See also B.S.P., Vol. 8, p. 440, S. Key 340.

Special aids to diagnosis

suitable sponge. The sponge and its contents are fixed, embedded in paraffin, sectioned a
stained for examination The method is described in detail. When carcinoma of the cer
presents no visible changes the sponge is rubbed over the area where the lesion beg

Case I. A 40-year-old married woman complained of back pain. There was no menstrual

oophorectomy were performed. The mucosa of the cervical canal was thickened to 4·0 millimetres near the external os and a small ulcer was seen in this area. Microscopic examination confirmed the diagnosis of epidermoid carcinoma of the cervix. Case II A

ty of men-
the cervix,
confirmed
ormed and

examination of the specimen showed an ulcer 7 millimetres in diameter on the lip of the cervix. Microscopical examination confirmed the presence of an epidermoid carcinoma of the cervix.

dase activity has been noted in mammary carcinoma and involved lymph nodes, and gastric, intestinal and metastatic carcinoma than in normal tissues. The method of deter-

Comparative exfoliative cytologic diagnosis.—NIEBURGS and PUND (1950) discuss the detection of cancer of the cervix uteri by comparative exfoliative cytologic diagnosis Routine vaginal smears from 10,000 women were studied over 3 years. When malignant cells or atypical cells suggestive of cancer were found, a diagnostic curettage and cervical biopsy were carried out. Smears were classified according to the method of Papanicolaou in classes 1 to 5 Classes 1 and 2 are considered negative, class 3 equivocal and classes 4 and 5

invasive cancer works out at about 135 dollars.

Gladstone, S. A (1949). *New Engl. J. Med*, 241, 48.
Nieburgs, H E, and Pund, E. R. (1950) *J. Amer. med. Ass*, 142, 221.
Odell, L. D., and Burt, J. C. (1950) *J. Amer. med. Ass*, 124, 226.

UTERUS—CERVIX; AND VAGINA

See also B.S.P., Vol. 8, p. 451, S. Key 341.

New growths of the vagina

Radium therapy of malignant lesions of the vagina.—Radium therapy of primary carcinoma and other malignant lesions of the vagina is discussed by FRICKE, BOWING and DECKER (1950). It has been estimated that only 1–2 per cent of all malignant neoplasms of the female genital tract are primary in the vagina. Radium and x-ray therapy are now the accepted methods of treatment; u
is unknown; no single
examination; adequate
and biopsy and micros
improve women in the
menopau es of primary
vaginal me incidental
surgical procedures were performed, treatment in all cases was primarily by radium or x-ray therapy or both. The lesions were squamous-cell epitheliomas in 42 of the cases; of the remaining cases, 4 were adenocarcinomas, 1 leimyosarcoma, 1 melano-epithelioma, 1 haemangio-endothelioma, and 1 lymphosarcoma. The results of treatment show that a gradual improvement in the survival rate has coincided with an improvement in radium

Fricke, R. E., Bowing, H. H., and Decker, D. G. (1950). *Amer. J. Roentgenol*, 64, 86.

VASCULAR SURGERY

See also B.S.P., Vol. 8, p. 489, S. Key 343

Coarctation of the aorta

Persistent hypertension due to coarctation of the aorta and its operative treatment.—Persistent hypertension in young adults is sometimes due to coarctation of the aorta. Surgical correction gives results better than those of the untreated disease, and ADAMS, RUTLEDGE and SOUDERS (1949) describe the syndrome and its operative treatment. It is

erect, may become visible when he bends forward (Campbell and Suzman's sign);
a rough systolic murmur
being loudly audible in
ves; notching of the ribs
y be dangerous. End-to-
end anas of 25 years. In older
patients, Exposure is obtained
through dividing the fourth,
sixth and l pleura. In 5 cases
oldest 36 years) two types of coarctation were

ood pressure
to 3 weeks.

Pulmonary stenosis

Aortic vascular rings encountered in congenital pulmonary stenosis.—BAHNSON and BLALOCK (1950) discuss aortic vascular rings encountered in the treatment of congenital pulmonary stenosis in 841 patients. Variations of an aortic vascular ring have been

encountered in 40 instances. The 3 forms observed are: a subclavian artery which arises from the medial side of the aortic arch as its last branch and passes behind the oesophagus to the contralateral arm, a retro-oesophageal innominate artery, and the persistence of both right and left embryonic fourth aortic arches. During the first 3 weeks of embryonic life 6 aortic arches join the ventral aortic sac and the dorsal paired aortas around the interposed pharynx. Caudal to the branchial arches the paired aortas become fused into the dorsal aorta. The left fourth arch becomes the aortic arch. The proximal part of the right fourth arch becomes the first portion of the subclavian artery. The right third arch persists as the proximal part of the carotid artery. Rarely the left subclavian artery may ascend to the third arch and a left innominate artery results. If the left fourth arch becomes obliterated instead of the right a right aortic arch results, an anomaly present in about 20 per cent of

arch which also forms the origin of the left pulmonary artery. When both fourth arches persist a complete aortic ring is formed about the trachea and oesophagus A retro-oesophageal subclavian artery is well adapted for the creation of an artificial ductus arteriosus. A retro-oesophageal artery may indent the oesophagus on barium swallow. Angiocardiography may demonstrate an anomalous vessel or aortic arch.

Anaesthesia

Anaesthesia for surgery of the heart and great vessels.—Rink (1950) discusses the problems facing the anaesthetist in cases for surgery on heart and great vessels. The patient himself is

reduced to a minimum, and provision made for more oxygen than usual, their colour may even be better than at rest in bed; but the slightest anoxic incident in induction or recovery may cause serious deterioration, and even death. Such cases, however, often have chronic respiratory infections which cannot be materially improved until the cardiac condition is

inter-

tively.

poor

tube. Inhalation and intravenous methods have been used, but he prefers the former, to

with a full

he surgeon

al sac and

myocardium itself Recently Rink has been administering procaine intravenously. Finally, means must be taken to ensure that adequate replacement of any blood lost can be immediately undertaken. The author reminds us that a successful operation improves the general condition, often dramatically. Deterioration during operation may therefore be an indication for proceeding as quickly as possible.

Operative

7 weeks old

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d atresia with pulmonary stenosis,

an interventricular septal defect.

The pulmonary artery and aorta were anastamosed and 5 intercostal vessels ligated Recovery was excellent. Cyanosis disappeared, the murmur remained. The second infant was also persistently cyanosed, even in oxygen. The same diagnosis was made. Anastomosis was performed, recovery was uneventful. The murmur persisted, becoming continuous It is important in deciding on

operation to be sure that there is no pulsation in the pulmonary fields, indicating adequate or excessive pulmonary blood supply.

Congenital and acquired heart disease.—Surgeons at the "Blue Baby Centre" in Paris have not been slow in following the lead of American surgeons. DONZELOT and his colleagues (1949) report the results of surgical treatment of cases of congenital and acquired heart disease at this Centre during a period of 18 months. Of the 570 patients with congenital cardiac disease examined at the Centre, 140 were operated upon for the tetralogy of Fallot, with a mortality rate of 15 per cent and a success rate of 75 per cent as judged by considerable

in choosing a left-sided approach almost exclusively, and in preferring an end-to-end to an end-to-side one. All patients who survived for 36 hours after operation had a satisfactory result. Only twice was the operation impracticable because of an incorrect pre-operative diagnosis. Exploration without anastomosis did not have an adverse effect on the patient's

was observed in the
disappeared, right
complication in the
early ambulation.

Recently anastomosis of the pulmonary vein to the azygos vein has been carried out in cases of mitral stenosis with oedema in order to shunt blood from the pulmonary vein to the right auricle and thus to relieve pulmonary embarrassment. The last two operations are indicated in cases in which medical treatment has failed.

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axillary artery, the splenic vein or the azygos vein; (2) reduction of the right ventricular

pressure of the pulsations when only this is required. Two mishaps may
operation: (1) introduction of the hook into the inferior vena cava; this is indicated by

other
longed
patients: there was only one failure, in which sudden collapse,

systolic and diastolic pressures were brought down to normal and remained so during observation over a period of 2 months.

section popular mainly because it does not produce Horner's syndrome as does cervico-

post-operatively following various technical procedures. Even when hypoglycaemic crises obtained by insulin produced adrenaline from the patient's suprarenal glands, the results were as obtained with adrenaline administered artificially. Goetz points out that results quoted from experimental animals do not necessarily hold for man. He warns against sentimental procrastination which sometimes throws away the opportunity of actually saving the limb. Demoralizing continuous ischaemic pain may be due to ischaemic neuritis rather than ischaemia of tissues, and if plethysmographs prove sufficient blood-flow for nutrition then nerve section should be performed as soon as pain becomes unbearable to permit adequate treatment being undertaken. Gangrenous patches must be treated by surgical first principles and suitable debridement undertaken, draining pus, removing necrotic tissue and using antibiotics and antiseptics Local amputation of toes or forefoot after such preliminaries may save an entire limb His experience with sympathectomy has been entirely pleasing, with a review of 400 sympathectomies without a single death, but he warns against omitting routine plethysmography in investigations, since only in this way can the collateral circulation be measured If such tests contra-indicate operation, then to persist with sympathectomy merely prolongs the patient's tortures The plethysmograph will also assist in determining suitable pressures for intermittent venous occlusion therapy. He uses hypertonic saline injections provided the cardiac musculature can take the extra burden, and finds this assists the recognized methods of treatment by vasodilator drugs and prohibited smoking.

Regional heparinization in vascular surgery—FREEMAN, WYLIE and GILFILLAN (1950) describe their experiences of regional heparinization in vascular surgery Five cases are described in detail in which heparin was injected into an artery so as to increase the clotting time locally without change of the clotting time in the general circulation. Murray and Best first described this procedure. The authors find that regional heparinization is of value in preventing thrombosis at an arterial suture-line, while decreasing the risk of haemorrhage from the wound itself. In the first case an embolus was removed from a common femoral artery 29 hours after impaction, together with a resulting thrombus from the superficial

was continued for 20 minutes; 5 weeks later arteriogram showed no occlusion of the vessel. In the third case 75 millilitres of heparin solution was given into a common femoral artery after embolectomy of both that vessel and its branches 8 hours after commencement of symptoms; but here prolonged general anticoagulant therapy was given in addition because of auricular fibrillation and a "stroke" one week previously, with recurrent haemorrhage from the wound necessitating twice reopening the wound to obtain haemostasis. The fourth case was the only mortality. Removal of a 3-day-old embolus at the bifurcation of the aorta, extending down to the left femoral artery, was followed 4 days later by a further embolus

at the same site,
removed. Region
inserted in retrog
continued by slo
peritone
intact.
artery
the ope
2 week normal.

Maintenance of life by mechanical heart and lung during occlusion of the venae ca

the human patient would permit of operations being performed within the chambers of the heart under direct vision and without fatal loss of blood. In the present experiments, blood is withdrawn from the animal through cannulae in the
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hum

slight haemolysis always occurred; (*b*) oxygenation was sometimes inadequate; (*c*) during perfusion with the venae cavae

survived and showed no signs of organic damage, clinically or at necropsy some months later. Eight dogs survived periods of complete occlusion of the venae cavae of 30–46 minutes, in which the apparatus carried the entire cardiorespiratory function; 4 surviving dogs are alive and healthy 8–10 months after the experiment.

Adams, H. D., Rutledge, D I., and Souders, C. R. (1949) *J. Amer. med. Ass*, **139**, 362
Bahnson, H. T., and Blalock, A (1950) *Ann. Surg.*, **131**, 356.
Cossio, P., and Perianes, I (1949). *J. Amer. med Ass.*, **140**, 989.
Donzelot, E., d'Allaines, F., and colleagues. (1949). *Bull. Acad. Méd. Paris*, **133**, 498.
Freeman, N. E., Wylie, E J, and Gilfillan, R. S. (1950). *Surg. Gynec. Obstet.*, **90**, 406.
Gasul, B. M., Fell, E. H., Marina, J. J., and Davis, C. B., Jun. (1949) *Amer. J. Dis. Child.*, **78**, 16.
Goetz, R. H. (1949). *Brit. J. Surg.*, **34**, 146.
Rink, E. H. (1950). *Ann. R. Coll. Surg Engl*, **7**, 151
Stokes, T. L., and Gibbon, J. H., Jun. (1950). *Surg. Gynec. Obstet.*, **91**, 138.

VEINS—VARICOSE

See also B S.P., Vol. 8, p. 529, S. Key 344.

Treatment of primary varices

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